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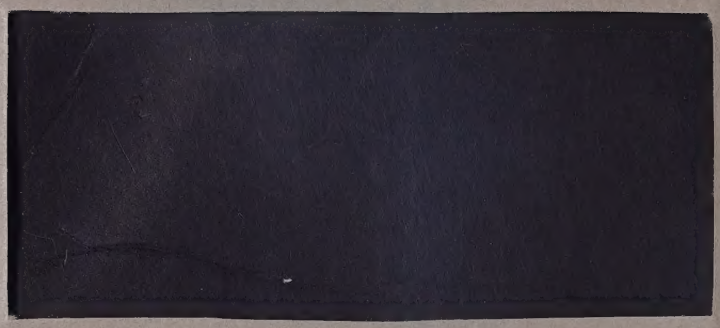
MODEL ~~231~~ 230R
RESISTANCE MEASURING SYSTEM
INSTRUCTION MANUAL

BAC 524224

RETURN TO
AEROSPACE DIV.



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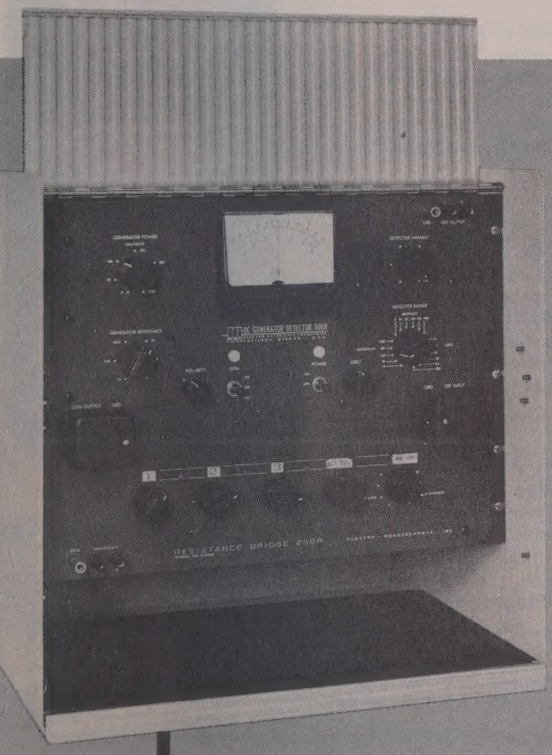
NEW PRODUCT
Catalog Sheet

BRIDGES AND ACCESSORIES
C-21

AUGUST 1960
REPLACES JANUARY 1960



model 231 RESISTANCE MEASURING SYSTEM

The ESI Model 231 RESISTANCE MEASURING SYSTEM consists of a precision Wheatstone Bridge featuring guarded construction and a matched generator-detector unit. Accurate, high resolution measurements are possible to 12 kilomegohms. Guarded construction and a unique circuit permit measurements even in a high ambient humidity without problems from leakage resistance. Adjustable generator output and a detector of extreme sensitivity assure measurements of rated accuracy throughout the measurement range.

The ESI Model 230-R RESISTANCE BRIDGE is a very accurate, high resolution, guarded Wheatstone Bridge, human engineered for simple operation and direct readout. Ratio adjustments are provided for each range to assure an accuracy limited only by available standards. To take full advantage of this ratio accuracy, the variable resistance arm is a precision five-place decade rheostat initially adjusted to an accuracy of ±(0.003% + one dial division) with an expected long-term stability of ±0.003%.

The ESI Model 800-R GENERATOR-DETECTOR is a combination of a variable power supply and a sensitive microvoltmeter. The generator provides 6 output ranges to match loads from 1 ohm to 100 kilohms. The output is continuously variable from 0 to 1 watt into a matched load. The isolation and guarding make the 800-R particularly applicable to high accuracy bridge measurements. The detector consists of a modulator type calibrated dc microvoltmeter, with ranges from 0.2μv per dial division to 1,000 volts full scale.

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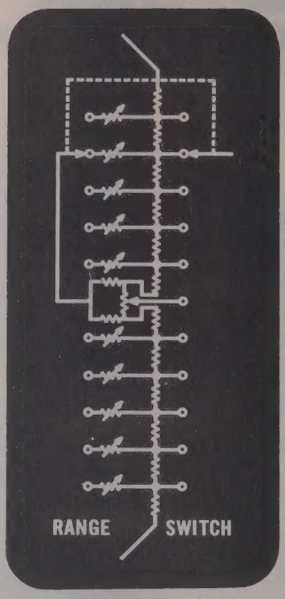
Resistance Bridge
Model 230-R

Featuring



improved ratio switching

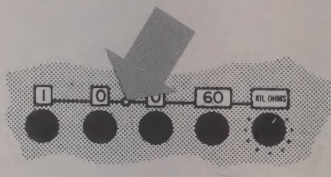
A special circuit has been employed to prevent the range switching circuit from impairing the bridge accuracy. The range switching circuit is designed so that switch contacts never appear in series with a low resistance bridge arm. This permits long term stability and high accuracy even at extreme ranges.

adjustable ratios

A ratio adjustment is provided for each range setting so that each range can be independently adjusted to a known reference standard. This unique feature permits the ratio to be adjusted to an accuracy limited only by available standards. To take full advantage of this ratio accuracy, the variable resistance arm is a precision five place decade rheostat initially adjusted to an accuracy of ±(0.003% + one dial division).

internal guarding

The ESI 230-R Resistance Bridge is constructed on an internal chassis which is insulated from the outer case. This chassis is connected to the bridge circuit in such a way that insulation leakages do not fall across the measured resistance. This permits accurate measurement of high resistance values.



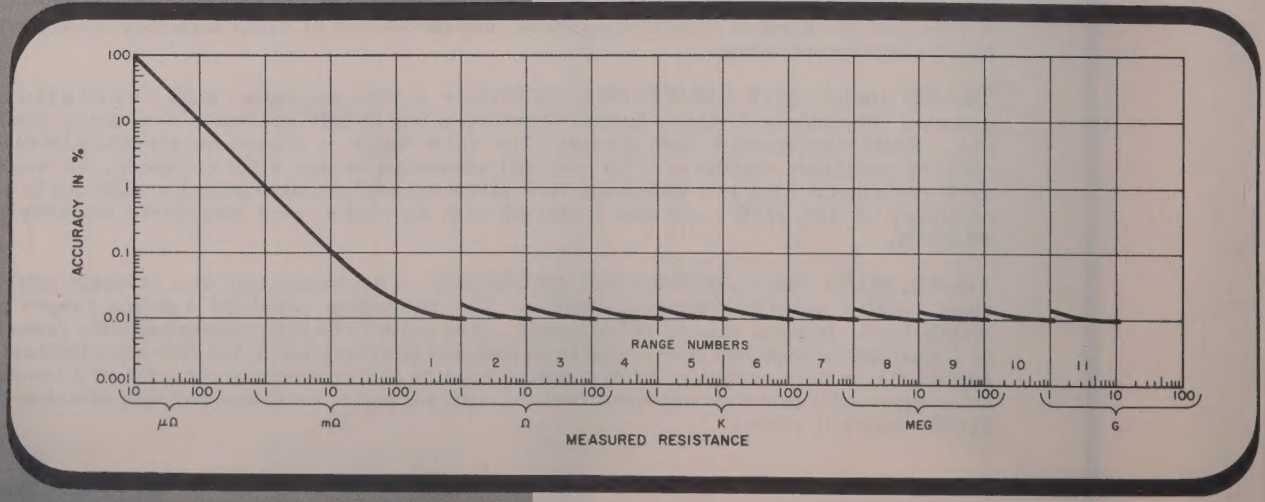
automatic decimal point

The bridge has been so designed that the range switch automatically sets the decimal point and indicates the unit of resistance.

The use of three decade dials and a 105 division interpolating dial insures rapid and accurate bridge balances.

Straight line arrangement of the control knobs permits operation without visual attention.

Accuracy



Specifications

MODEL 231 RESISTANCE MEASURING SYSTEM

The ESI Model 231 Resistance Measuring System consists of an ESI Model 230-R Resistance Bridge and an ESI Model 800-R DC Generator-Detector in an attractive, convenient cabinet.

Dimensions: 20.0" high, 19.5" long, 15.1" deep
Weight: 71 lbs net. 95 lbs packed for shipment
Price: $1,875 f.o.b. Portland, Oregon

MODEL 230-R RESISTANCE BRIDGE

Resistance Range: 0 to 12 kilomegohms in eleven ranges (10 microhms per dial division on lowest range).
Accuracy: ±(0.01% + 1 dial division) when corrected for short circuit resistance.
Resolution: Three decade switches and a 105 division interpolating rheostat provide 120,000 dial divisions of resolution.
Reading Presentation: The readings appear in windows in a straight line across the panel. The unit of measurement (milliohms, ohms, kilohms, megohms, kilomegohms) appears beside the reading and the decimal point is automatically placed in its proper location.
Mounting: The instrument is designed for standard racks having 19" width.

Dimensions: 5 1/4" high, 19" long, 7" deep
Weight: 10 lbs net. 20 lbs packed for shipment
Price: $450 f.o.b. Portland, Oregon

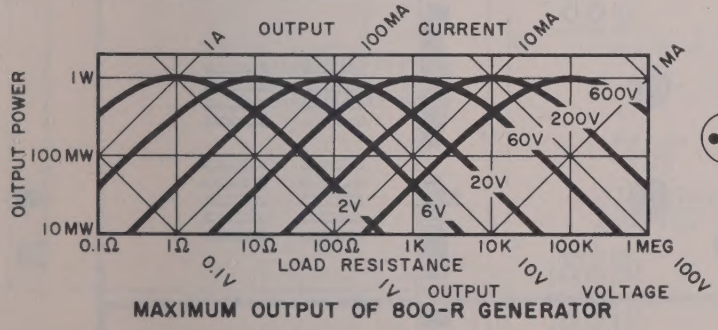
MODEL 800-R GENERATOR DETECTOR

GENERATOR

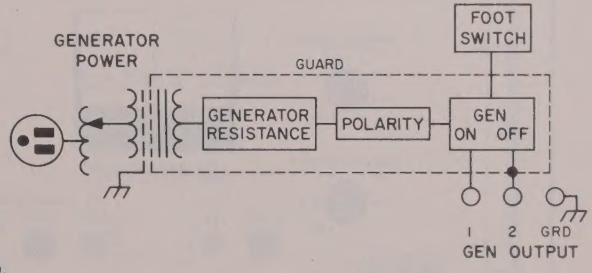
Range Switch: 6 positions with safety interlock on 200 v and 600 v ranges.

OPEN CIRCUIT VOLTAGE (VOLTS)	2	6	20	60	200	600
SHORT CIRCUIT CURRENT (MA)	2,000	600	200	60	20	6
OUTPUT RESISTANCE (OHMS)	1	10	100	1K	10K	100K

Output Control: Continuously variable from 0 to 1000 mw into matched load.
Leakage Resistance: Terminal 1 greater than 10^{14} ohms: Terminal 2 greater than 10^{11} ohms.



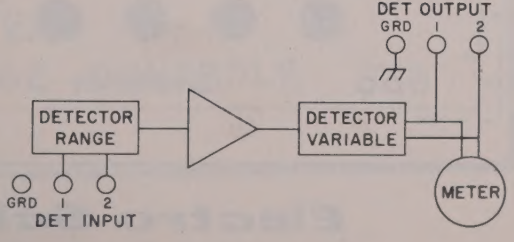
MAXIMUM OUTPUT OF 800-R GENERATOR



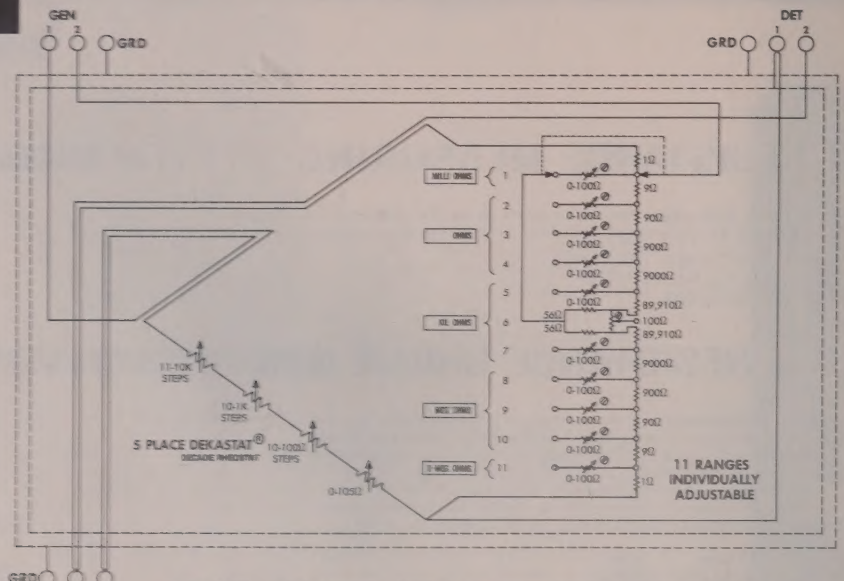
DETECTOR

Voltage Range: 0 to 1000 volts. 0.2 microvolts per division on lowest range.
Hum Rejection: Approximately 60 db at 60 cps.
Input Resistance: 1.2 megohms.
Output Voltage: Approximately 1 volt max. for full scale.
Output Resistance: 0 to 2500Ω depending on output setting.

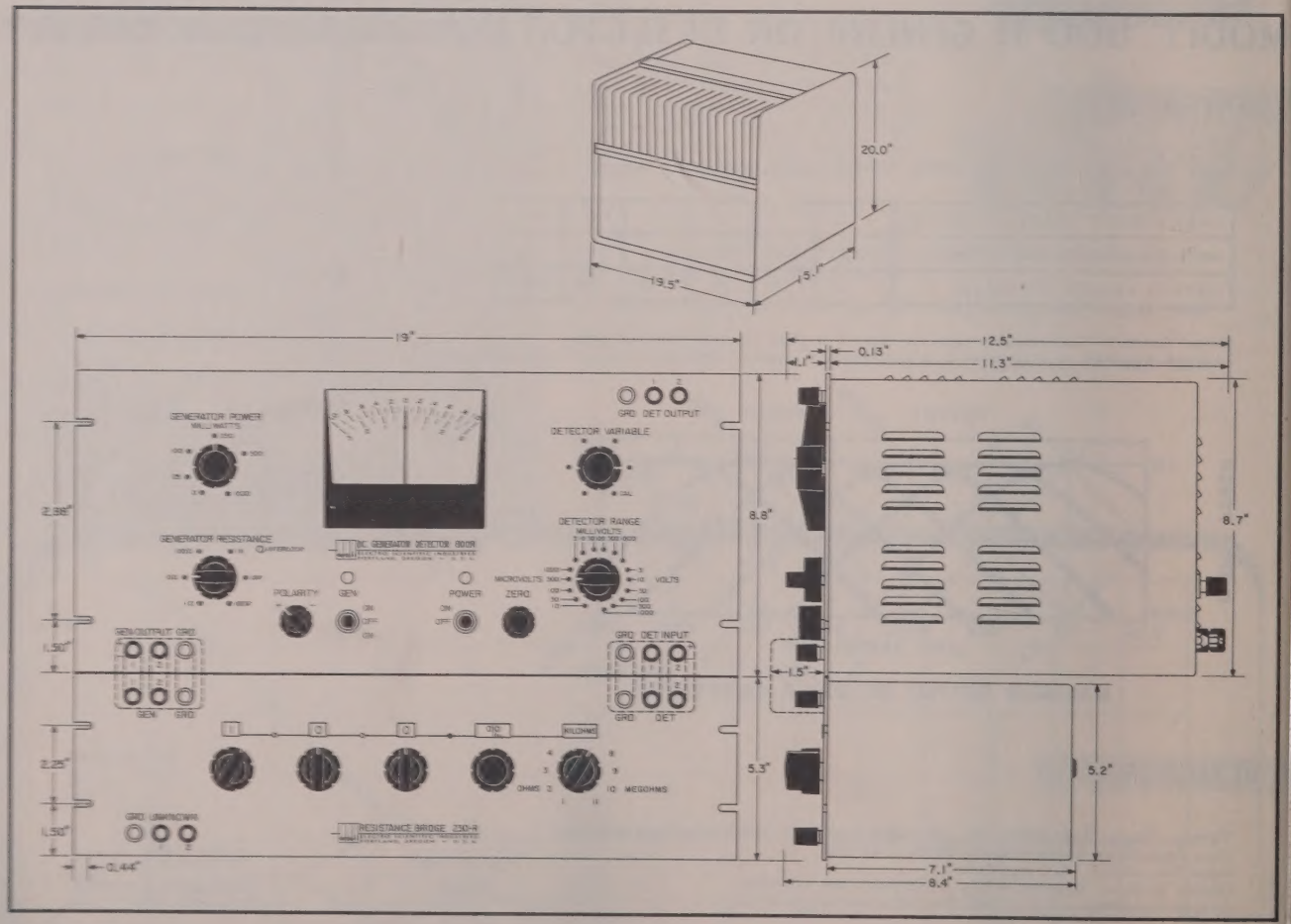
Dimensions: 8 3/4" high, 19" long, 12" deep
Weight: 35 lbs net. 55 lbs packed for shipment
Price: $1,300 f.o.b. Portland, Oregon



Model 231 RESISTANCE MEASURING SYSTEM



esi MODEL 230-R CIRCUIT DIAGRAM



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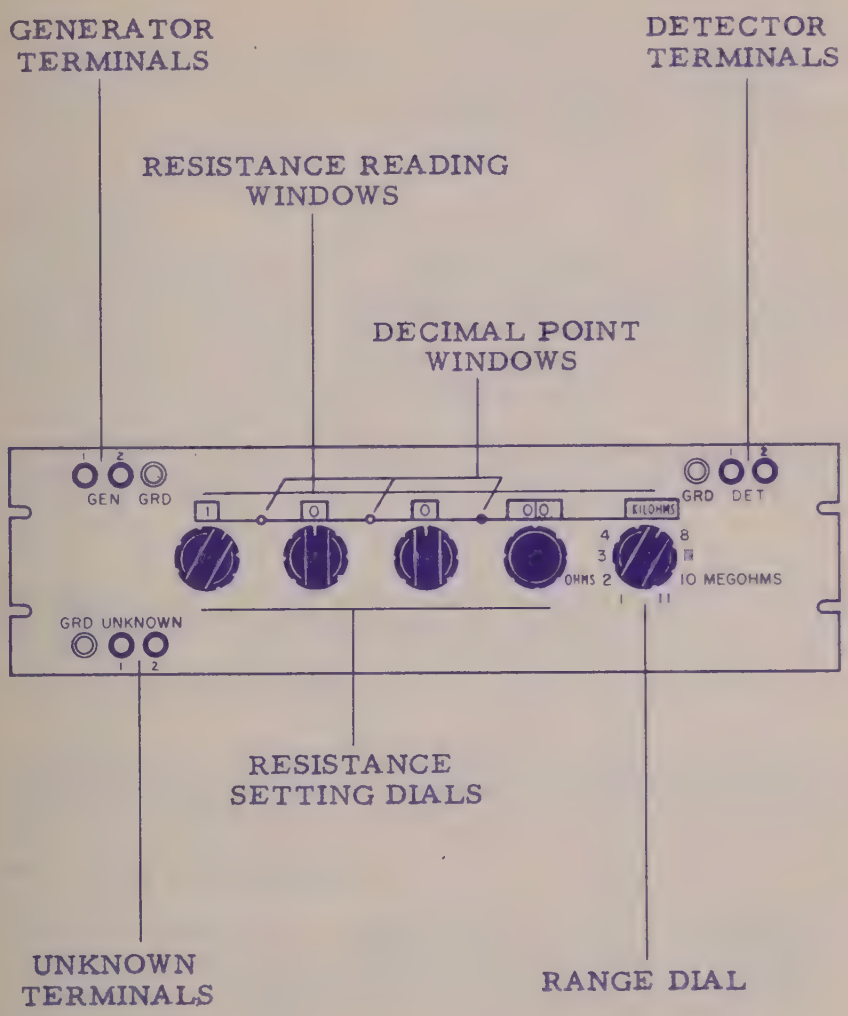


model 230

RESISTANCE BRIDGE CONTROLS

1. CONTROLS

1.1 RANGE DIAL

The right hand dial chooses from 11 resistance ratios, places the measurement unit used in the window and locates the decimal point in the appropriate position for accurate and convenient readout.

1.2 RESISTANCE SETTING DIALS

The four left hand dials are used for setting the value of the unknown resistor. The straight line arrangement of the control knobs permits operation without visual attention.

1.3 RESISTANCE READING WINDOWS

The windows across the top of the bridge present an in-line resistance reading including decimal point and units.

1.4 DECIMAL POINT WINDOWS

The three small round windows above the dials are for the visual presentation of the decimal point.

1.5 GENERATOR TERMINALS

The upper left hand terminals of the bridge are for attaching an external generator. An adjacent ground terminal has been provided for convenience.

1.6 DETECTOR TERMINALS

The upper right hand terminals of the bridge are for the attachment of an external detector. An adjacent ground terminal has been provided for convenience.

1.7 UNKNOWN TERMINALS

The lower left hand terminals of the bridge are for the attachment of the unknown resistor. An adjacent ground terminal has been provided for convenience.

2. OPERATING INSTRUCTIONS

2.1 WHAT THE BRIDGE MEASURES

The 230-R Resistance Bridge will measure an infinite number of resistance values between 0 and 12 kilomegohms by means of a conventional Wheatstone Bridge circuit. The five place read-out combined with the eleven ranges enables the operator to make leakage resistance measurements in thousands of megohms or contact resistance measurements in milliohms with equal ease.

2.2 GENERATOR REQUIREMENTS

The ESI Model 840-R Generator and Detector will permit bridge measurements with full accuracy for resistance values between one ohm and ten megohms. For normal operation a dc generator is required which will supply a maximum of ONE WATT to the bridge generator terminals from 1 ohm to 100 kilohms, depending on the dial settings.

CAUTION: At no time should generator open circuit voltage exceeding 700 volts be used with the bridge.

IMPORTANT: For bridge protection and reliability it is necessary that the maximum available power to the bridge be limited to ONE WATT. This is accomplished by a resistor in series with the generator or battery. The value of this resistance can be calculated from the following formula:

$$R_L = \frac{E^2}{4}$$

where,

R_L is the value of the power limiting resistor

E is the open circuit voltage of the external generator or battery

The protective resistor should have a power rating of 4 watts or more. Input power should be limited to 1/10 watt or less for most accurate measurements.

For best sensitivity and maximum accuracy with convenient power sources and standard value resistors, the following voltages are recommended:

RANGE	GEN E.	LIMITING RESISTOR
0 to 120Ω	6 volts	10Ω 5 W
120Ω to 10 megΩ	90 volts	2.2K 5 W
10 megΩ to 12 K megΩ	300 to 700 volts	25K 5 W to 120K 5 W

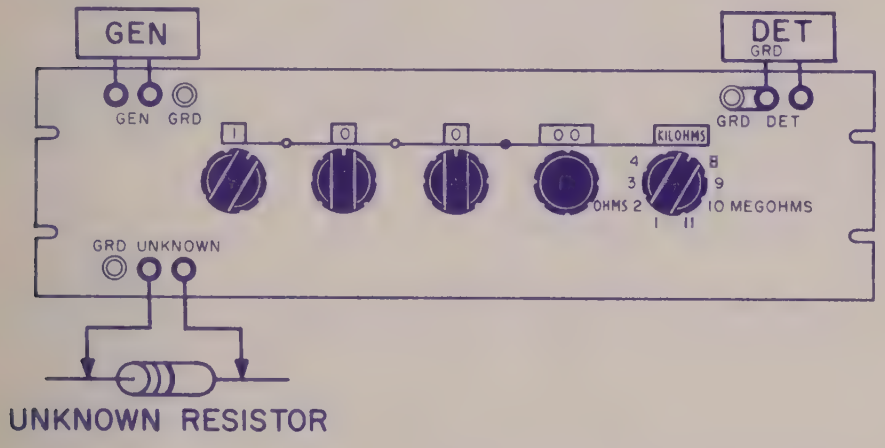
2.3 DETECTOR REQUIREMENTS

The ESI Model 840-R Generator and Detector will permit bridge measurements with full accuracy for resistance values between one ohm and ten megohms. The output impedance of the 230-R RESISTANCE BRIDGE is approximately 100K ohms. A detector designed to operate from a source of 100K ohms will yield optimum performance. A mismatch of ten to one in either direction will not seriously impair the sensitivity. Sensitivity of 10 μv and 100 μμa per dial division will permit measurements to rated accuracy for resistance values to 500 megohms.

2.4 MEASURING RESISTORS

2.4.1 OPERATING CONDITIONS

The Model 230 Resistance Bridge is factory calibrated for better than rated accuracy under laboratory conditions. For maximum accuracy an ambient temperature of 25°C and a relative humidity less than 50% should be maintained. The power input to the bridge should be reduced to one-tenth maximum power or less if adequate detector sensitivity is available. At high humidity internal bridge errors are held to a negligible amount by the guarded construction, but care should be taken that the accuracy is not impaired by leakage currents in the generator or detector.



2.4.2 BASIC INSTRUCTIONS

1. CONNECT THE EXTERNAL DC GENERATOR AND DETECTOR TO THE BRIDGE TERMINALS.	WARNING: Limit the generator output to one watt maximum. The ESI 840 has limiter built in.
2. CONNECT THE RESISTOR TO THE UNKNOWN TERMINALS.	Make good contact with terminals.
3. SET THE FIRST FOUR DIALS TO 1.	A null will be reached rapidly with this setting.
4. SET THE RANGE DIAL TO THE LOWEST RANGE.	This will avoid random null hunting.
5. TURN ON GENERATOR.	Be sure power input is always limited to 1 W.

2.4 MEASURING RESISTORS (cont.)

6. ADJUST THE RANGE SWITCH. Switch thru increasing ranges until the detector indicates a null has been passed. Switch back one range.

7. ADJUST THE RESISTANCE SETTING DIALS. Increase the first dial until a null is passed. Switch back one position. Increase the second dial until a null is passed. Switch back one position. Increase the sensitivity as needed. Etc.

840-R Power Switch Position	Resistance
10 V	0 to 0.1 kilohms
300 V	0.1 kilohms to 12 kilomegs

8. REVERSE THE GENERATOR POLARITY. This check eliminates errors resulting from thermoelectric potentials. A proper null has been reached if there is no detector deflection.

9. READ DIRECTLY THE VALUE OF UNKNOWN RESISTANCE. The bridge reading is given complete with decimal and units.

2.4.3 THINGS TO WATCH OUT FOR

2.4.3.1 LOW RESISTANCE MEASUREMENTS (Zero Resistance)

On the lowest ranges of the 230-R Bridge, the lead resistance in the unknown arm becomes significant. A correction for this resistance can be made as follows:

1. Short the test leads together at the point they are to be connected to the unknown resistor and measure this "zero resistance".

2. Connect the test leads to the unknown resistor and measure the "unknown resistance".

3. The "measured value" of the unknown resistor is then the "unknown resistance" minus the "zero resistance".

4. If the unknown resistor is to be connected directly to the terminals, the "zero resistance" reading can be taken by connecting a piece of heavy copper wire between the unknown resistance terminals. Zero resistance should be less than 1 milliohm. (No. 14 AWG copper wire has a resistance of about 0.21 milliohms/inch. The bridge has a maximum resolution of 0.01 milliohm per dial division.)

2.4.3.1 LOW RESISTANCE MEASUREMENTS (cont.)

Sometimes thermal voltages are generated at connections and these can lead to erroneous balances of the bridge. If this condition is suspected, balance the bridge then reverse the generator polarity. If this results in a different detector reading, change the resistance setting dials until the detector reads the same for both generator polarities. This cancels the effect of the thermal voltages.

2.4.3.2 HIGH RESISTANCE MEASUREMENTS

This bridge will measure resistances to 12,000 megohms with rated accuracy. This requires a sensitive detector having a long time constant and low internal noise. For best sensitivity and maximum accuracy the voltages listed under 2.2 Generator Requirements should be used.

Generator voltage must not exceed 700 volts and must have a current limiting series resistance of

$$R_L = \frac{E^2}{4}$$

ohms where E is the open circuit voltage of the supply.

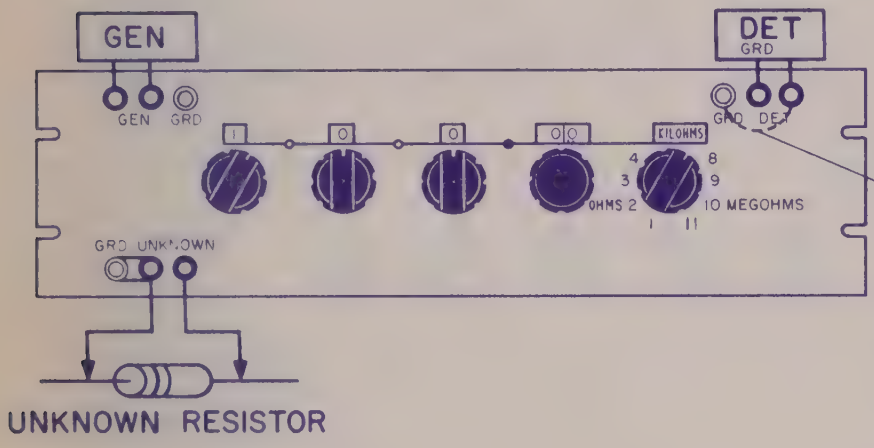
Care should be taken when making high resistance measurements to eliminate or minimize leakages across the unknown. If this condition is suspected a three terminal resistance measurement should be made if possible. (See Section 2.4.5)

2.4.4 TWO-TERMINAL RESISTANCE MEASUREMENTS

2.4.4.1 UNGROUNDED TWO-TERMINAL MEASUREMENTS

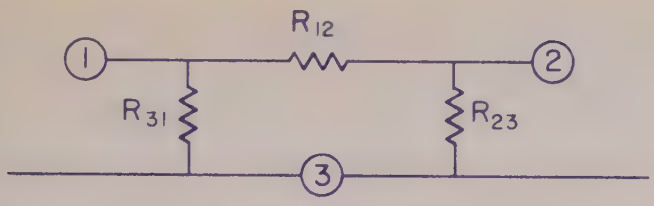
The majority of measurements made on the 230 Resistance Bridge will be two-terminal ungrounded measurements. This type of measurement is accomplished by attaching the "unknown resistance" to the bridge unknown terminals No. 1 and No. 2.

2.4.4.2 GROUNDED TWO-TERMINAL MEASUREMENTS

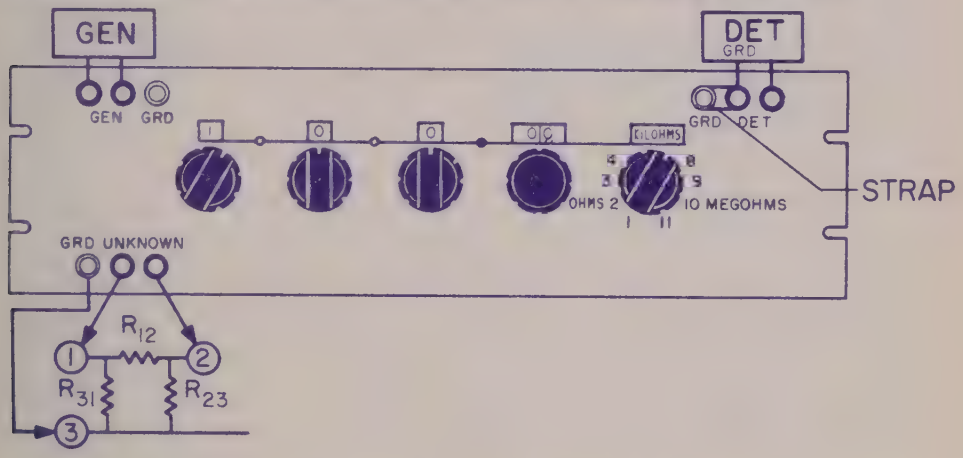


CONNECT A STRAP FROM "UNKNOWN" TERMINAL NO. 1 TO GROUND.	As an alternate connection the detector terminal No. 2 can be grounded. Don't ground both places. If this connection is made anywhere in the external circuit don't ground either one. A ground loop can cause errors.
MEASURE THE RESISTANCE.	Proceed as in 2.4.2.

2.4.5 THREE-TERMINAL MEASUREMENTS



With the above circuit it is often possible to measure R_{12} quite accurately even though R_{31} and R_{23} are of a much lower value than R_{12}. This is done by connecting ① and ② to the unknown terminals of the bridge and ③ to either detector terminal No. 1 or generator terminal No. 2. Thus one of the resistors is shunted across the generator or detector and causes no error but may reduce sensitivity. The other is placed across an internal arm of the bridge where it may cause an error but its effect can often be calculated to permit a reading correction.



FOR R_{31} AND R_{23} BOTH GREATER THAN 1 KILOMEGOHM:

CONNECT A STRAP BETWEEN DETECTOR TERMINAL NO. 1 AND GROUND.	This completes the necessary bridge connections.
CONNECT ① AND ② TO THE UNKNOWN TERMINALS.	This permits the desired measurements.
CONNECT ③ TO THE GROUND TERMINAL.	
MEASURE THE RESISTANCE.	Proceed as in 2.4.2. The value read will be R_{12} only.

If R_{31} is a low resistance and R_{23} is greater than 1 kilomegohm, connect 1 to the unknown terminal No. 1, ② to unknown terminal No. 2 and ③ to ground. This places the low resistance across the detector and so it will cause no measurement error but may reduce the detector sensitivity.

3. PREVENTIVE MAINTENANCE

A monthly check and a yearly maintenance program will insure a long trouble-free bridge life.

3.1 MONTHLY CHECK ITEMS

Item No.	What To Check	How To Check
1	Panel, dials, knobs, windows	Clean with soft brush
2	Binding posts and insulators	Clean off wax and dirt with soft cloth
3	Oxide formed on switch contacts	Rotate each switch several times to assure good contact before making measurement

3.2 YEARLY CHECK ITEMS

3.2.1 REMOVAL OF CHASSIS FROM DUST COVER

Prepare a soft, clean place to set the instrument. Be sure that no projections or pointed objects will be underneath the bridge panel. See that there are no metal filings around or above the exposed wiring and parts of the bridge.

Remove the instrument from the rack, remove the dust cover and place the instrument on the prepared surface.

3.2.2 YEARLY CHECK LIST

Item No.	What To Check	How To Check	Precautions
1	Wiring and solder joints	Look for loose wires and frayed or worn insulation.	DO NOT probe, heat, or in any other way disturb the precision resistors.
2	Resistors	Look for discoloration due to heat, open resistors.	(See above)
3	Switch Decks	Check for proper engagement and continuity. Oil all switch rotors.	Use #2008 Oak lubricant or equivalent.*
4	Nuts on ends of basic assemblies	Moderately tight, secure with Glyptal.	DO NOT get cement in contacts.
5	Clean and lubricate	All prescribed parts cleaned and lubricated.	Look for fungus growths and mildew in tropical locations.

*Oak Mfg. Co.
Chicago, Ill.

3.2.3 REPLACEMENT OF CHASSIS IN DUST COVER

1. Be sure that the interior of the dust cover is completely clear of all foreign material.

2. Place bridge in dust cover being very careful not to touch dust cover against bridge resistors. Replace dust cover screws.

3. Replace assembled instrument in rack, tighten mounting screws thoroughly.

4. SERVICING AND REPAIR

NOTE: Unnecessary disassembly of the bridge may cause additional trouble instead of correcting the existing trouble.

If possible, the instrument should be returned to the factory or to an authorized service facility if trouble is suspected. If this is impractical the following procedure is recommended.

4.1 PRELIMINARY CHECKING

1. Check the panel controls to insure that they are positioned according to instructions covering the specific measurement being performed. It has been found in many cases that failure to obtain a bridge balance has been due to the wrong position of one or more of the panel controls.

2. Check connections between the bridge binding posts and the part under measurement. What appears to be an intermittent condition inside the instrument may be merely a poor outside connection.

4.2 CHECKING PROCEDURE

NOTE: The bridge operator must acquire a knowledge of abnormal outside conditions that are reflected in unsatisfactory bridge operation so that tampering with the bridge will be avoided.

When it has been ascertained that the difficulty is not due to outside causes, the following procedures should be followed in conjunction with the trouble shooting chart.

CAUTION: Unqualified personnel must not tamper with the bridge. Unauthorized repairs will invalidate our warranty. If the tests outlined in the following paragraphs indicate the need for major repairs, our service department will be glad to furnish necessary repair information as well as any replacement parts. If the instrument is more than one year old, a reasonable charge may be expected for replacement parts or for complete reconditioning if the instrument is returned to the factory.

4.2.1 TEST EQUIPMENT AND TOOLS

Tool or Test Equipment	Use
A Wheatstone bridge	For accurate resistance measurements.
Laboratory resistance standards	For checking accuracy of resistance readings.
A screw driver	To remove bridge from dust cover.
Allen-head wrenches, #8 hexagon	To loosen or tighten set screws.

4.2.2 TROUBLE SHOOTING CHART

Symptom	Probable Cause of Trouble	Procedure
Bridge inoperative	Loose or improper external connections	Check all binding post connections.
	Generator or detector not operating	Check operation of generator and detector.
	Internal bridge trouble	See below.
Questionable operation	Faulty wiring	Check wiring to be sure that no short circuits exist.
	Faulty switch	Check all switches for proper contacts and operation.
Questionable reading or erratic operation	Open, shorted, or defective resistor	Test range for open and shorted circuits and rated values.
	Faulty decade	Check decades for continuity and for accuracy of resistance values corresponding to settings of the decades.
Readings inaccurate	Decade dials or range dials in wrong position on shaft.	Check decade dial location. Check range dial location.
	Faulty range assembly	Check resistor for continuity and accuracy.
	Slipped range dial	Check range switch against dial setting.

4.3 BRIDGE CHASSIS AND COMPONENTS

4.3.1 INSPECTION

If further tests are necessary to locate trouble, and if adequate facilities are available, the bridge may be tested internally.

Referring to the basic bridge circuits and the schematic diagrams, use a multimeter to test the various bridge circuits for continuity.

Continuity tests and resistor measurements are important aids in locating trouble, but be sure to consider and investigate the physical condition of switch contacts, switch arms, soldered connections, and other items covered in previous paragraphs. Trouble may be caused by excessive oxidation on the switch contacts. When making continuity tests of the switches, check for short circuits, loose connections, corrosion, cold-soldered joints, etc., as possible causes of erroneous readings.

4.3.2 LUBRICATION

If switch lubrication is indicated, proceed as follows:

1. Apply a thin coating of #2008 Oak lubricant or equivalent with a hypodermic needle to the contact surfaces of the rotary switches.

2. Apply two drops of the same oil to each of the switch bearings and detent mechanisms.

3. Remove excess oil with a clean, dry cloth and remove all traces of lint with a soft brush.

4. Detent balls should have film of light grease.

4.3.3 SETTING THE DIALS

In order to check that the dials are in their proper position with respect to the switch shaft, the following procedure can be carried out without difficulty:

4.3.3.1 DECADE DIALS

1. Attach an ohmmeter between Unknown No. 2 terminal and Detector No. 1 terminal.

2. Turn the farthest left-hand dial counter clockwise through all positions and note the position giving the lowest reading. This is the zero position.

3. Follow the same procedure as above for the other two decades and rheostat.

4.3.3.2 RANGE DIAL

1. Attach an ohmmeter to No. 1 Unknown and No. 2 Generator terminals.

2. Disregard the decade setting.

3. Turn the range dial through all eleven positions and note the position that gives the lowest reading. This is the only milliohm position.

4 BRIDGE CALIBRATION

The 230-R Resistance Bridge has been thoroughly inspected and accurately calibrated at the factory. Before any attempts are made to recalibrate the bridge, the operator must acquire a knowledge of abnormal outside conditions that are reflected in unsatisfactory bridge operation so that tampering with the bridge will be avoided.

If, however, the operator wishes to recalibrate the bridge without returning it to the factory, the following procedure is recommended:

PROCEDURE

4.4.1 TEST EQUIPMENT AND TOOLS

Tool or Test Equipment	Use
A Wheatstone bridge	For accurate resistance measurements.
Laboratory resistance standards	For checking accuracy of resistance readings and adjusting Ratio Trimmers.
A screw driver	To remove bridge from dust cover.

4.4.2 DEKASTAT® CHECK

1.	Set all resistance reading to "0".	Range setting does not matter.
2.	Measure "zero resistance" of DEKASTAT®	Measuring instrument must be capable of seeing ±0.001% from 0 to 120K ohms. Measure from unknown 2 terminal to detector 1 terminal.
3.	Measure resistance at 10 div points on fourth dial and every step on third, second and first dials.	These readings should be within ±0.010%. "Zero resistance" must be subtracted.

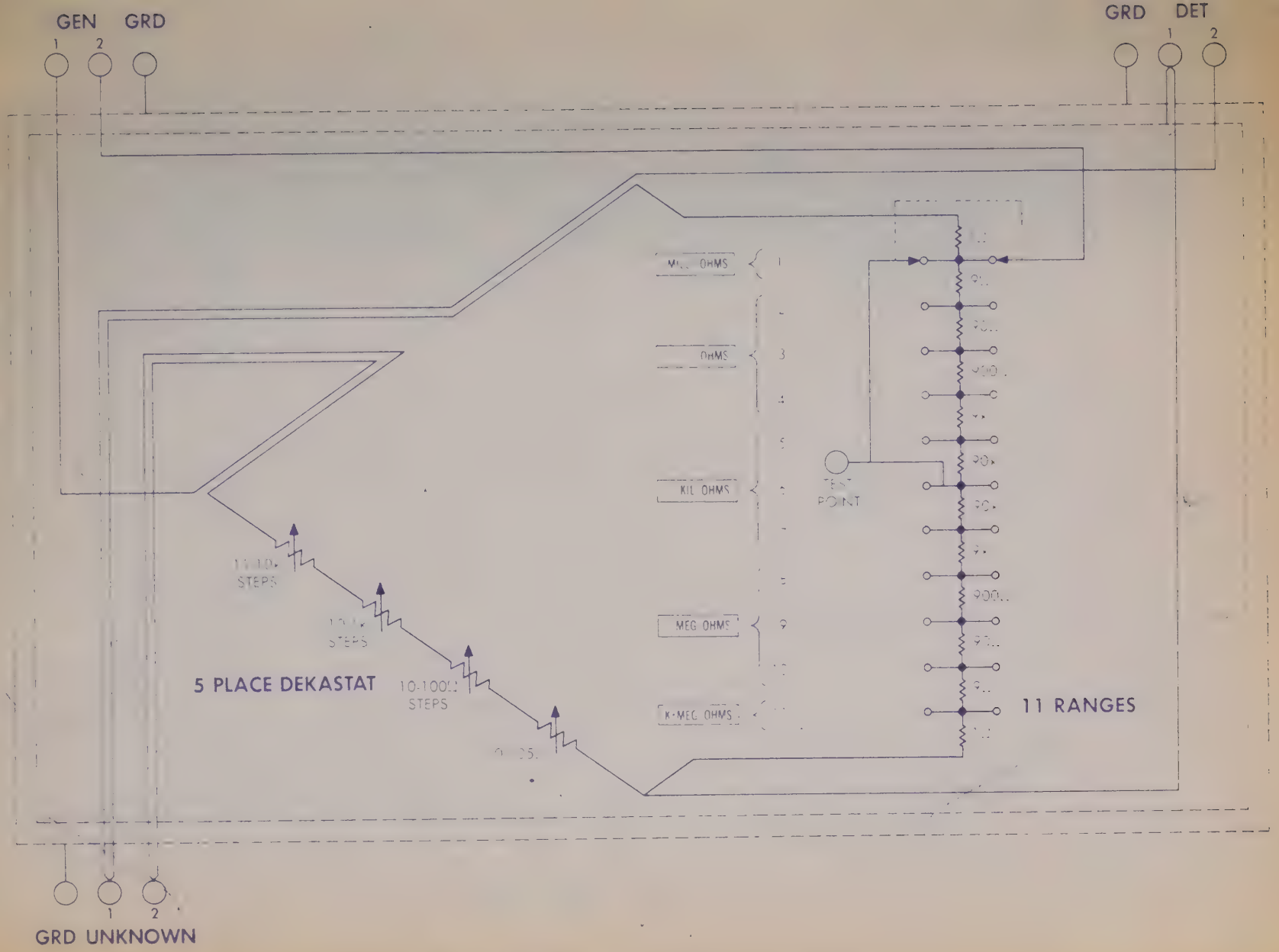
4.4.3 RANGE CHECK

1.	Connect appropriate generator and detector.	A functional calibration procedure for the range ratios on the lowest eight ranges (1Ω to 10 megohms) is recommended.
2.	Connect standard resistor to unknown terminals	Subtract "zero resistance" (or lead resistance) below 1 K.

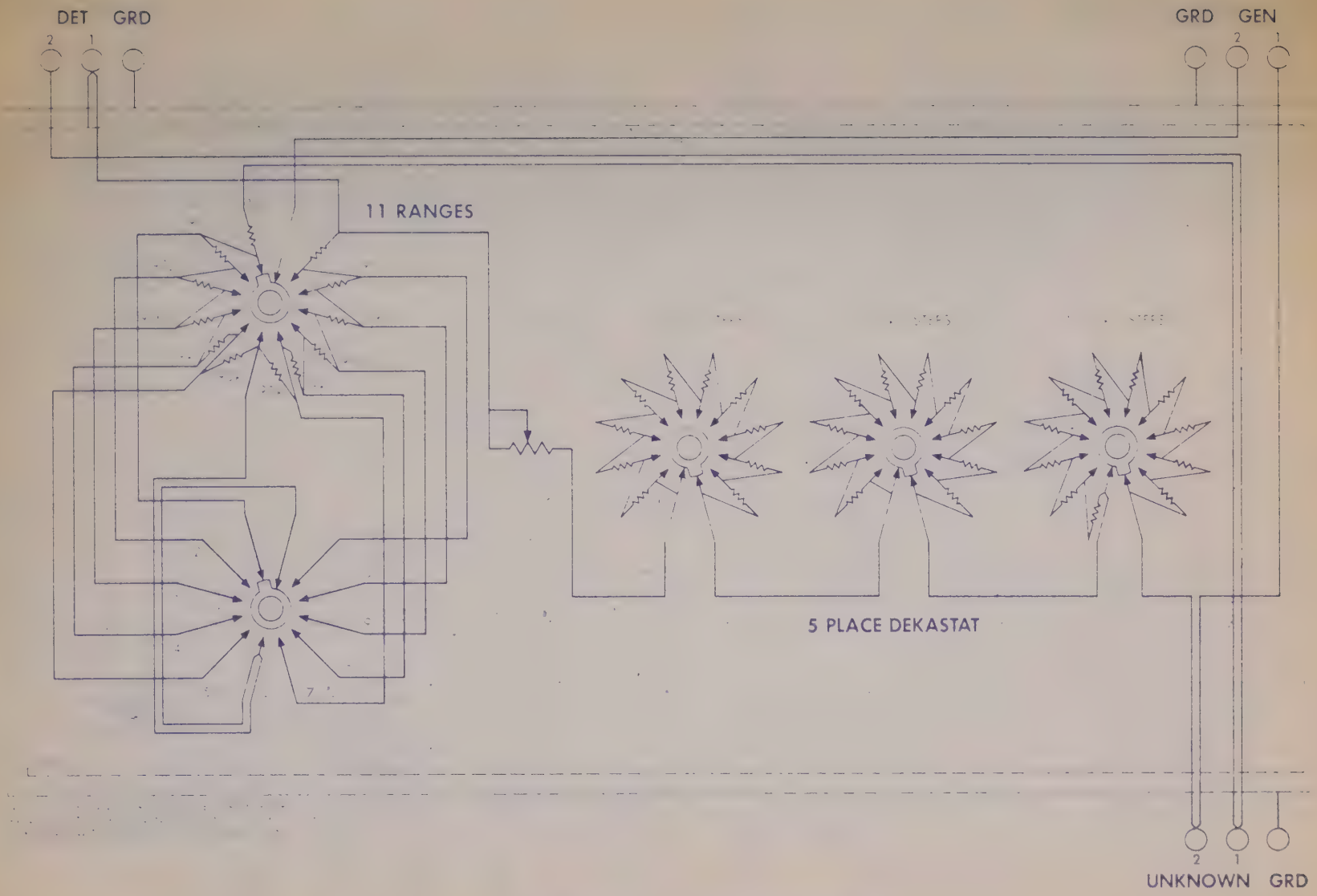
R_1	Resistor Assy.	10k	VA10k	11
R_2	Resistor Assy.	1k	VA 1k	10
R_3	Resistor Assy.	100Ω	VA100	10
R_4	Rheostat Assy.	105Ω, 315°	6719	1
R_5,R_{29}	Resistor Assy.	0.9946Ω	VA.9946	1
$R_{6,8,10,12,14,17}$ $R_{20,22,24,26,28}$	Trimmer Resistor, 100Ω. 25 Turn		2339	11
R_7,R_{27}	Resistor Assy.	9Ω	VA 9	2
R_9,R_{25}	Resistor Assy.	90Ω	VA90	2
R_{11},R_{23}	Resistor Assy.	900Ω	VA900	2
R_{13},R_{21}	Resistor Assy.	9k	VA 9k	2
R_{15},R_{19}	Resistor Assy.	89,910Ω	VA89,910	2
R_{16},R_{18}	Resistor, 56Ω, 1/2W, 10% AB			2
R_{29}	Resistor Assy.	0.9994Ω	VA.9994	1

Switches

$S_{1,2,3}$	Switch Assy.	12 pos. Oak	6706	3
S_4	Range Resistor-Switch Assy.		2335	1



MODEL 230 A CIRCUIT DIAGRAM



MODEL 230A WIRING DIAGRAM

INSTRUCTION MANUAL

For

THE ESI MODEL 800-R

GENERATOR-DETECTOR

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1. GENERAL DESCRIPTION

1.1 Discussion

The 800-R is a dc generator and null detector (microvoltmeter). The generator features double-chassis construction, or guarding, to greatly reduce stray leakage paths to ground. Leakage from the "high" generator terminal to ground has been completely eliminated. Insulation of the other terminal is kept to 10^{11} ohms or greater.

The output of the generator is continuously variable and is limited to a maximum of one watt into a matched load. A front panel control selects six output ranges to match loads from 1 ohm to 100 kilohms.

An automatic switching sequence allows the detector to remain connected to the bridge circuit except for approximately 2/3 seconds druing switching transients. Correction can thus be made for thermal voltages by zeroing the detector while it is connected to the bridge circuit. At the same time, large transient voltages are prevented from causing a "zero" shift in the detector.

The detector freatures a very sensitive modulator-type dc amplifier. Trouble caused by stray ac pickup from the device under test is greatly reduced by a rejection filter. The modulator operates below the ac line frequency, thus still further reducing the ac pickup. The detector is designed to be operated with one terminal grounded.

The unique design features of the 800-R make it suitable to a number of applications:

1. Very high resistance bridge measurements can be made with superior accuracy because of the special guarding and shielding features.

2. Very low resistance bridge measurements can also be made with high accuracy because of the detector sensitivity and the provision for matching the generator to the load.

3. The same features apply to make the 800-R an ideal generator-detector combination for calibrating precision voltage dividers. A detailed description of this application may be found in ESI's "Design Ideas", volume 1, number 1. See also Section 2.2 of this Manual.

4. The 800-R can be used directly to measure extremely low conductance (high resistance). See Section 2.3).

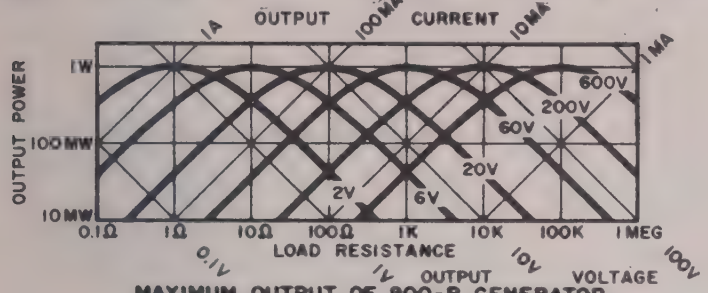
5. The 800-R generator can be used separately wherever a variable, guarded, and power-limited dc supply is needed.

6. The 800-R detector can be used separately as a microvoltmeter.

1.2 SPECIFICATIONS

1.2.1 GENERATOR

Range: 6 ranges, continuously variable, 0 to 600V. Power limited to 1 watt.



MAXIMUM OUTPUT OF 800-R GENERATOR

Leakage (insulation resistance): Terminal 1 greater than 10^{14} ohms;
Terminal 2 greater than 10^{11} ohms.

Output Resistance:

OPEN CIRCUIT VOLTAGE (VOLTS)	2	6	20	60	200	600
SHORT CIRCUIT CURRENT (MA)	2,000	600	200	60	20	6
OUTPUT RESISTANCE (OHMS)	1	10	100	1K	10K	100K

1.2.2 DETECTOR

Voltage Range: Positive and negative and scale voltages of 10, 30, and 100 microvolts; 0.3, 1, 3, 10, and 30 millivolts; 0.1, 0.3, 1, 3, 10, 30, 300, and 1000 volts. 0.2 microvolts per division on the lowest range.

Accuracy: Within ± 3% of end scale. Power line frequency variations of ± 5 cps affect accuracy less than ± 2%.

Input impedance: 1.2 megohms - operating
0.2 megohms - during switching.

Amplifier Gain: 100,000 maximum

Ac rejection: At least 3 db at 0.2 cps; 50 db at 50 cps, and approximately 60 db or more above 60 cps. A power line or twice power line frequency signal 40 db greater than end scale causes less than 1% error.

Output (for operating recorder, oscilloscope, etc.):

Voltage: 0 to 0.8 volts for end scale reading, adjustable.

Impedance: 200 ohms shunted by a tapped 5000 ohm potentiometer.

Noise: Less than 0.2 microvolts rms (typically less than 1.2 microvolts p-p) referred to the input.

Drift: After 15 minutes warm up, drift is less than ± 2 microvolts per hour referred to the input.

1.2.3 PHYSICAL

Height: 8-3/4 inches

Length: 19 inches

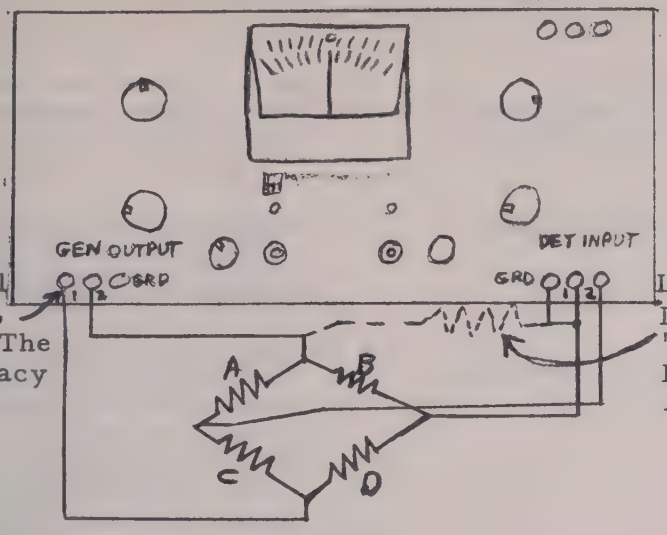
Depth: 11.43 inches

Weight: 25 lbs.

Power requirements: 115 v.a.c. ± 10%, 60 cps, 40 watts.

2. OPERATING INSTRUCTIONS

2.1 USING THE 800-R FOR BRIDGE MEASUREMENTS



Leakage Resistance From This Terminal Is Above 10^{14} ohms, And Will Not Affect The Measurement Accuracy

Leakage Resistance Is In Parallel With Arm "B". Arm "B" Should Be The Lowest Resistance Arm of the Bridge.

WARNING: BEFORE TOUCHING THE GENERATOR, OR ANY PART OF THE CIRCUIT, ALWAYS SET "GEN"SWITCH TO "OFF".

This will remove voltages from the generator terminals so that connections can be made safely.

WHEN CONNECTING THE BRIDGE TO THE 800-R, BE SURE THAT THE #2 TERMINAL OF THE GENERATOR IS CONNECTED TO THE BRIDGE GENERATOR INPUT TERMINAL HAVING THE LOWEST IMPEDANCE TO GROUND.

In this way, the leakage resistance to ground of generator terminal #2 will appear in parallel with a relatively low resistance bridge arm. Since the leakage resistance is extremely high, it will cause a very low percent error when in parallel with a low resistance bridge arm.

BE SURE GEN SWITCH IS OFF, THEN TURN THE INSTRUMENT POWER SWITCH ON, AND ALLOW SOME TIME FOR WARM-UP.

The lowest detector ranges require about 15; minutes warm-up for maximum stability.

SET DETECTOR RANGE TO THE 30 μv RANGE AND ADJUST ZERO CONTROLS FOR METER ZERO.

This should be done with the generator, detector, and bridge connected, so that the zero adjustment will cancel any thermoelectric voltages which may be present.

SET THE "DETECTOR RANGE"SWITCH TO THE ONE VOLT RANGE

This will avoid long "meter-recovery" delays caused by high bridge unbalance voltages, but will leave enough sensitivity for a very coarse balance.

SET THE "GENERATOR POWER" CONTROL TO A VALUE WHICH WILL NOT CAUSE RESISTOR VALUE DRIFT DUE TO HEATING.	A power setting lower than the rating of the lowest-rated resistor in the bridge circuit is always safe.
SET THE "DETECTOR VARIABLE" CONTROL TO "CAL".	The meter is most sensitive at this setting, and will also read the correct unbalance voltage of the bridge.
SET THE "GENERATOR RESISTANCE" CONTROL AS DESIRED.	This control may later be set to give a maximum detector reading. Such a point is reached by matching the generator output resistance to the bridge input resistance, and will result in the highest detector input voltage for a given bridge unbalance.
SET THE "POLARITY"SWITCH AS DESIRED.	The POLARITY SWITCH may be set to make themeter read positive and negative deflections with bridge dial changes.
PROCEED WITH THE BRIDGE MEASUREMENT IN A NORMAL WAY.	Obtain "Coarse", and then less and less "rough null balances by setting the DETECTOR RANGE switch to successively lower ranges, while manipulating the bridge dials.

The 800-R detector can be used for "go-no-go" bridge measurements.

To do this, proceed as follows:

1. WITH A STANDARD RESISTOR CONNECTED TO THE BRIDGE, BALANCE THE BRIDGE AS ABOVE.

   The bridge is now set to the standard value.

****

2. SET THE BRIDGE DIALS TO READ THE STANDARD VALUE PLUS THE UPPER TOLERANCE LIMIT.

   This will merely call for offsetting the above reading by the amount of tolerance.

****

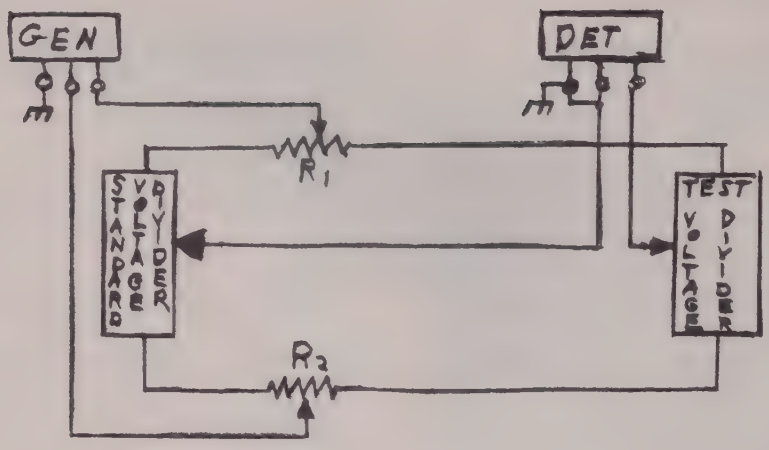
3. ADJUST THE DETECTOR VARIABLE CONTROL TO MAKE THE METER READ ON A MAJOR DIVISION, (i.e., 1,2,3, .5, 1.0, etc.)

****

4. DISCONNECT THE STANDARD AND CONNECT THE TEST RESISTORS ONE AT A TIME.

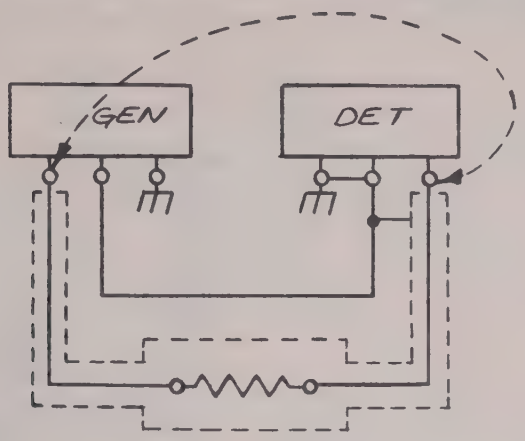
   Whenever the meter setting of step 4 is exceeded, the resistor under test is out of tolerance.

****



CONNECT THE TWO DIVIDERS AS SHOWN	R_1 and R_2 must be sufficient to provide equal voltage at each divider.
WARNING: BEFORE TOUCHING THE GENERATOR, OR ANY PART OF THE CIRCUIT, ALWAYS SET "GEN" SWITCH TO "OFF".	This will remove voltages from the generator terminals so that connections can be made safely.
TURN THE INSTRUMENT ON, AND ALLOW SOME TIME FOR WARM-UP.	The lowest detector ranges require about 15 minutes warm-up for maximum stability.
BE SURE GENERATOR SWITCH IS OFF, THEN SET THE DETECTOR RANGE TO THE 30 MICROVOLT RANGE AND ADJUST ZERO CONTROL FOR A METER ZERO	This should be done with the generator, detector, and divider connected, so that the zero adjustment will cancel any thermoelectric voltages which may be presen
SET THE DETECTOR RANGE SWITCH TO THE ONE VOLT RANGE	This will avoid long "meter recovery" delays caused by high bridge unbalance voltages, but will still leave enough sensitivity for a very rough null balance.
SET THE "GENERATOR POWER" CONTROL TO A VALUE WHICH WILL NOT CAUSE RESISTOR DRIFT DUE TO HEATING.	A power setting lower than the rating of the lowest-rated resistor in the bridge circuit is always a safe setting.
SET THE DETECTOR VARIABLE CONTROL TO CAL.	The meter is most sensitive at this setting and will also read the correct unbalance voltage of the divider.
SET THE GENERATOR RESISTANCE CONTROL AS DESIRED.	This control may later be set to give a maximum detector reading. Such a point is reached by matching the generator output resistance to the divider input resistance, and will result in the highest detector input voltage for a given divider unbalance.

2.3 USING THE 800-R AS A HIGH RESISTANCE OHMMETER



WARNING: Before touching the generator or any part of the circuit, always set generator switch to "OFF".

This will remove any voltages from the generator terminals so that connections can be made safely.

Connect the Generator and Detector as shown by the solid lines above.

Be sure to shield as shown.

Turn the instrument on, and allow some time for warm-up.

The lowest detector ranges require about 15 minutes warm-up for maximum stability.

Set the Detector Range Switch to 1000 volts, and the detector variable to CAL.

Connect a clip lead as shown by the dotted lines.

The detector will now read the open circuit voltage of the generator.

Set the Generator Resistance Control to 100 K. Set the Power Control to 1000.

The detector should read about 600V.

Remove the clip lead and lower the Detector range setting to get a reading as close to full scale as possible.

The value of R_1 is:

R_1 = The resistance to be measured

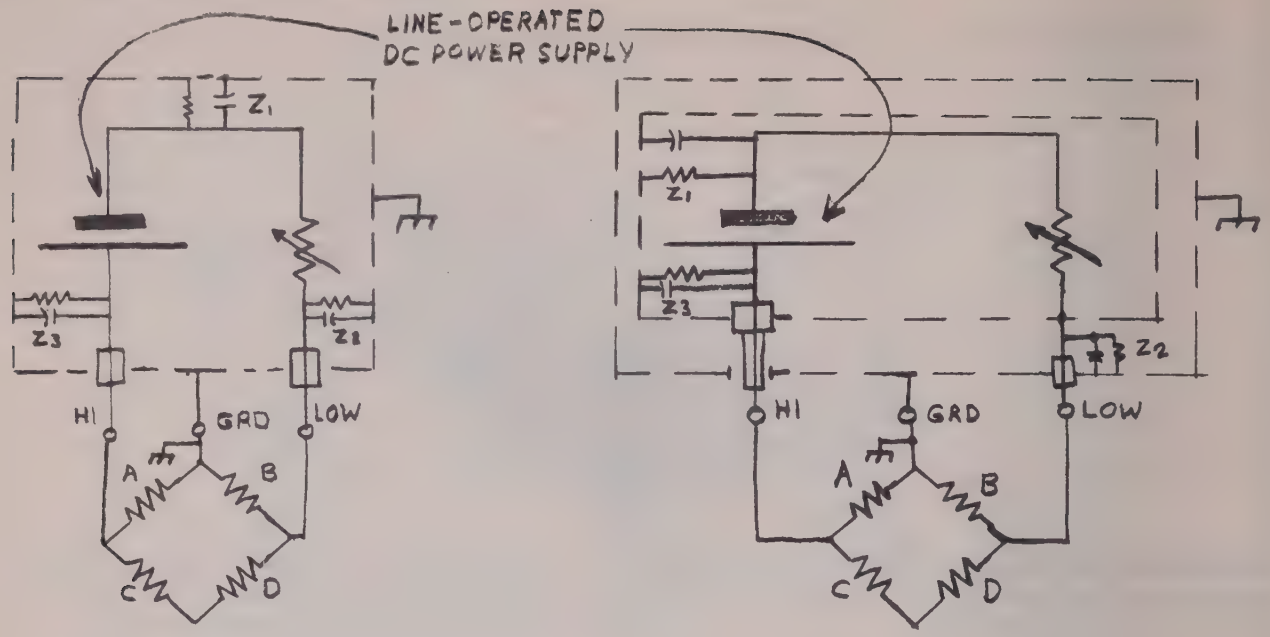
$1.2 \times 10^6 \Omega$ = detector input impedancae

V_g = Generator open circuit voltage.

V_d = Measured detector voltage.

$$R_1 = \frac{V_g}{V_d} \times 1.2 \times 10^6 \text{ ohms.}$$

3.0 THEORY OF OPERATION



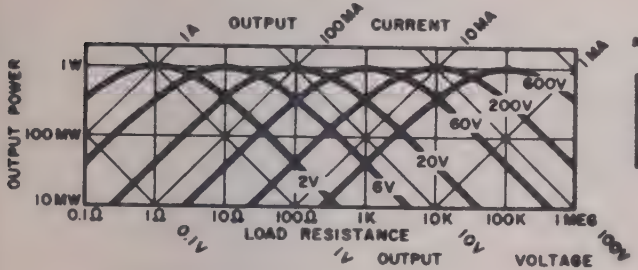
3.1 GENERATOR

The 800-R generator is a guarded dc power supply with variable output power and a provision for matching the output impedance to a wide range of values. The guarding of the generator makes accurate high resistance bridge measurements possible. The diagrams above illustrate how this is done. In the unguarded circuit at (A), the leakage impedances Z^2 and Z_3 appear in parallel with bridge arms A and B. If there were high resistance arms, an appreciable error would result. The leakage impedance Z_1 is also in parallel with each of arms A and B. Since this leakage is at a higher emf than those at the terminals, it will cause even more error. This leakage path will cause unbalance voltages of opposite polarity with respect to ground and will therefore be additive at the detector.

In the guarded circuit at (B), Z_1, Z_2 appear in parallel with the generator, and cause no trouble. Z_3 is kept to better than 10^{11} ohms by use of Kel-F insulators, both as a feed-through insulator for the LO terminal, and as support insulators for the guard chassis. By keeping bridge arm B (or whatever resistance is attached to the LO terminal) small, relative to 10^{11} ohms, no appreciable error is experienced. This circuit also keeps any ac voltage across Z_1 from getting into the detector via bridge arms A and B, since this ac voltage is returned to the low terminal.

The generator is line-operated. A continuously variable auto transformer feeds a tapped-secondary power transformer, which in turn supplies a rectifier and filter network. The primary of the power transformer is separately shielded and air-insulated from the core to prevent capacitive coupling and leakage of ac voltages to the guar

chassis. If an ac voltage were present on the guard chassis, it would appear from the LO output terminal to ground, and thus, directly across the bridge arm, B (Figure above) in bridge measurements. The ac would then appear on the detector and would cause an error in null reading. The separate shielding is connected to ground to prevent this error. The filtered dc is supplied to the output terminals through various resistance combinations. These combinations, plus tapped secondary rectifier combinations are controlled by the GENERATOR RESISTANCE switch on the front panel and make it possible for the generator output to match most load resistances. They also limit the output power to one watt.

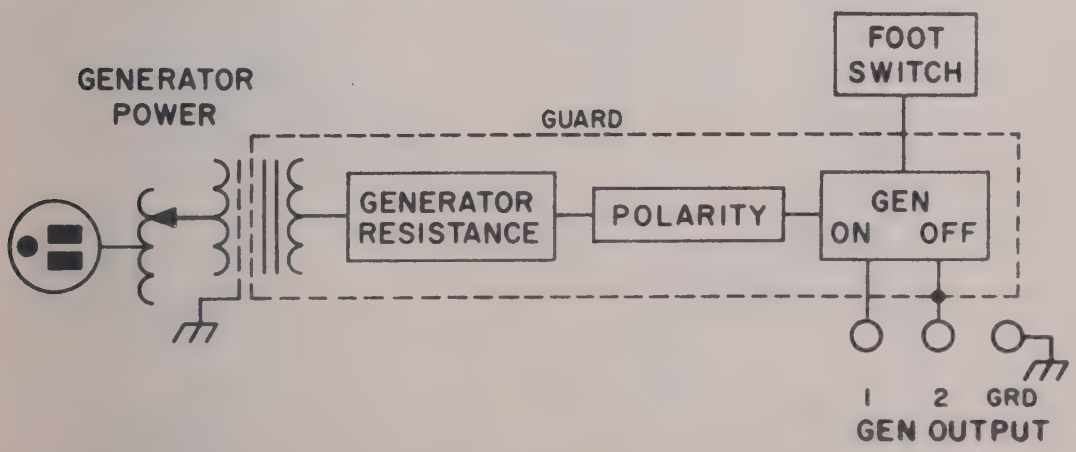


MAXIMUM OUTPUT OF 800-R GENERATOR

Range Switch: 6 positions with safety interlock on 200 v and 600 v ranges.

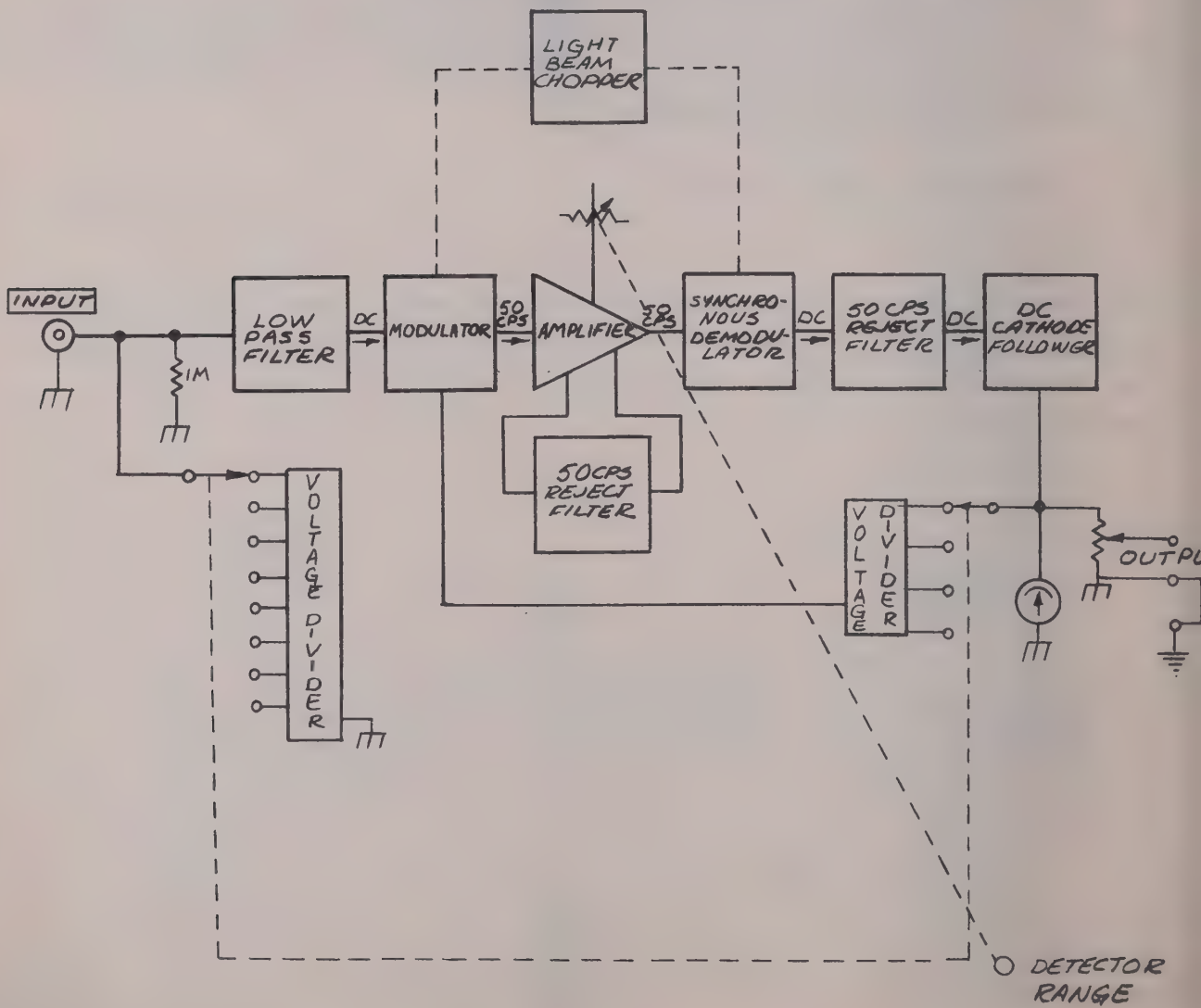
OPEN CIRCUIT VOLTAGE (VOLTS)	2	6	20	60	200	600
SHORT CIRCUIT CURRENT (MA)	2,000	600	200	60	20	0
OUTPUT RESISTANCE (OHMS)	1	10	100	1K	10K	100K

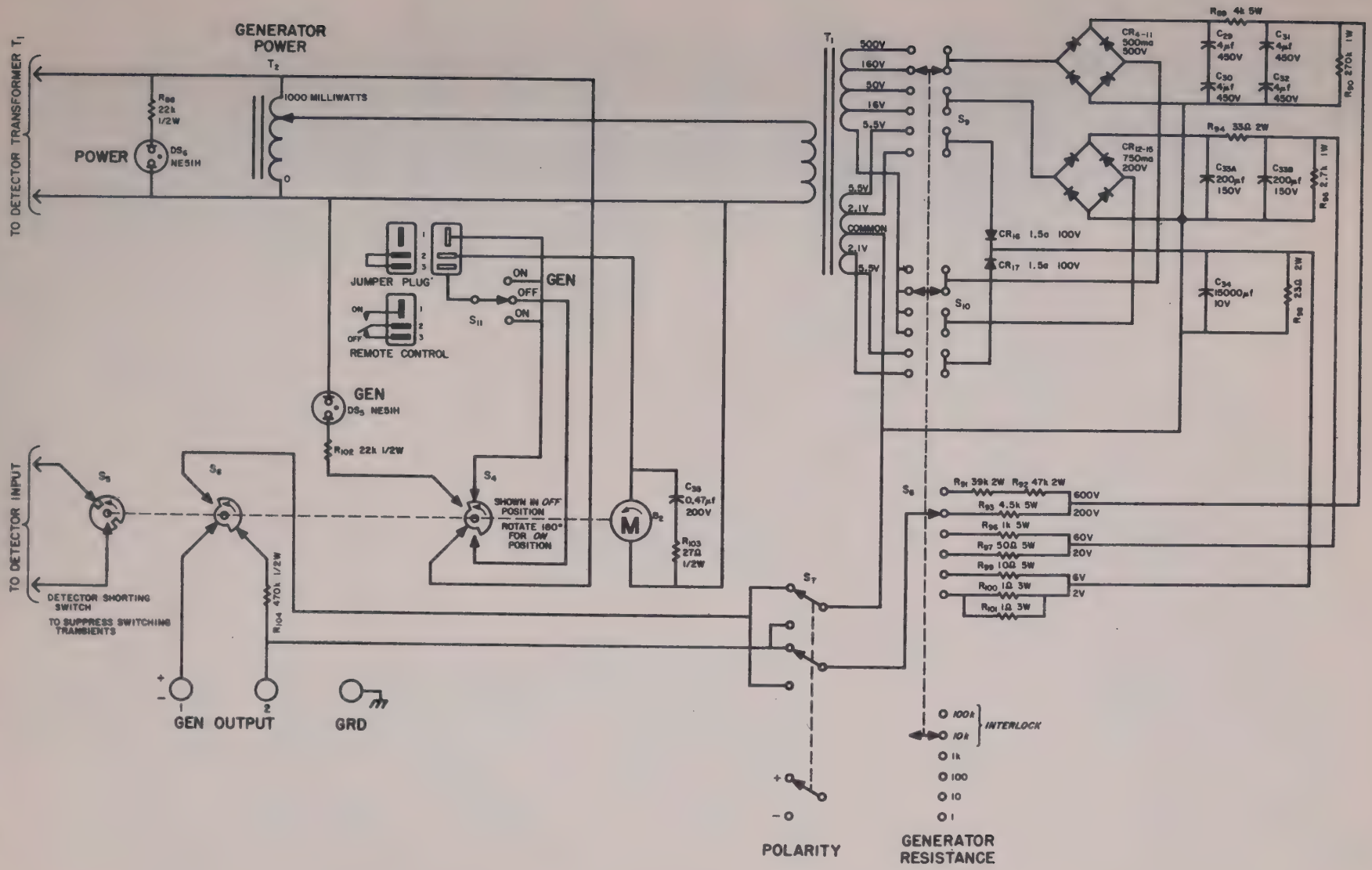
The generator power is supplied to the terminals through a motor-driven switching network. These controls momentarily disable the generator output during switching transients, and at the same time, connect a 470,000 ohm resistor across the generator output terminals.



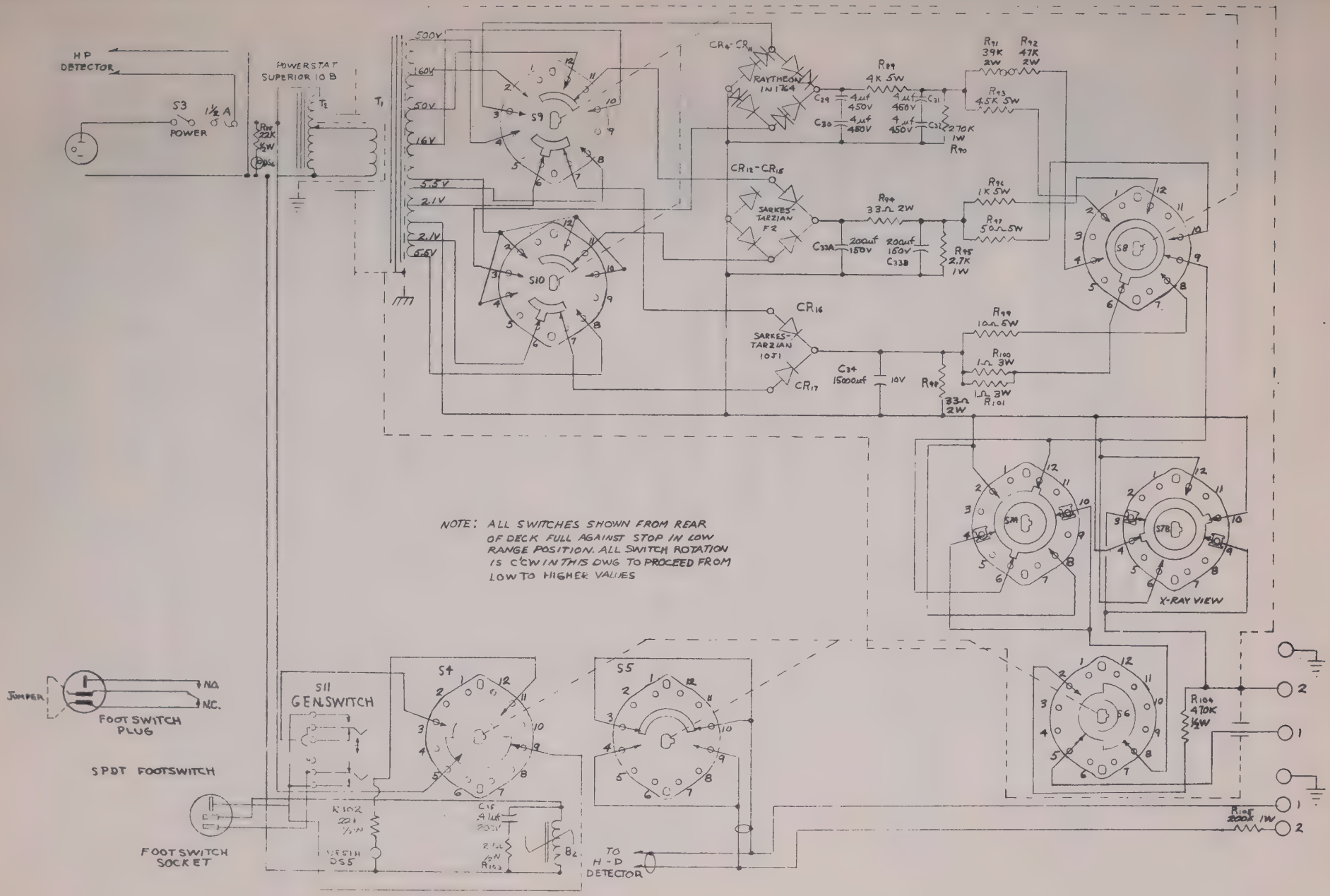
3.2 DETECTOR

The 800-R detector is a dc amplifier and sensitive microvoltmeter, as shown in the block diagram below. The input signal passes through a low-pass filter to eliminate ac. A photo-conductive modulator converts the filtered dc. to a square wave. The square wave is kept at 5/6 of the power line frequency by a light beam chopper. This signal is amplified by a high-gain ac amplifier, sharply tuned to the modulator frequency, with feedback through a rejection type filter. A demodulator, synchronized to the modulator by the light beam chopper, converts the amplifier output to dc. A second rejection filter attenuates any remaining fundamental frequency component of the demodulator output. A dc cathode follower drives the meter, the output circuit, and a feedback attenuator. The feedback attenuator determines the voltage gain of the circuit.





4.1 esi MODEL 800 DC GENERATOR CIRCUIT DIAGRAM


HP DETECTOR
POWERSTAT SUPERIOR 10 B
S3 1½ A
POWER
R98 22K ½W
500V
160V
50V
16V
5.5V
2.1V
2.1V
5.5V
T1
T2
S9
S10
CR6-CR11
RAYTHEON 1N1764
R89 4K 5W
R91 39K 2W
R92 47K 2W
R93 4.5K 5W
C29 4µf 450V
C30 4µf 450V
C31 4µf 450V
C32 4µf 450V
R90 270K 1W
CR12-CR15
SARKES-TARZIAN F2
R94 33Ω 2W
R95 1K 5W
R97 50Ω 5W
C33A 200µf 150V
C33B 200µf 150V
R96 2.7K 1W
S8
CR16
SARKES-TARZIAN 10J1
CR17
C34 15000µf 10V
R98 33Ω 2W
R99 10Ω 5W
R100 1Ω 3W
R101 1Ω 3W
S6M
S7B
X-RAY VIEW
NOTE: ALL SWITCHES SHOWN FROM REAR OF DECK FULL AGAINST STOP IN LOW RANGE POSITION. ALL SWITCH ROTATION IS C'CW IN THIS DWG TO PROCEED FROM LOW TO HIGHER VALUES
JUMPER
NO
NC.
FOOT SWITCH PLUG
SPDT FOOTSWITCH
FOOT SWITCH SOCKET
S11 GEN. SWITCH
S4
S5
R102 22Ω ½W
C15 4µf 200V
R103 2.7K ½W
B2
TO H-D DETECTOR
S6
R104 470K ½W
R105 200K 1W
2
1
1
2

5. MAINTENANCE

5.1 ROUTINE MAINTENANCE

5.1.1 Lubrication

The lubrication of the 800-R generator switches should be carried out at approximately yearly intervals. A very small amount of petroleum jelly (Vaseline), or equivalent, should be applied to the detent mechanism on all rotary switches.

5.1.2 Periodic Voltage Check.

Check on a one-year basis the output voltages for each GENERATOR RESISTANCE range. This is done as follows:

1. Turn instrument ON and allow 5 minutes to warm up.
2. Turn GENERATOR switch to OFF.
3. Set GENERATOR RESISTANCE to 1 ohm.
4. Set POLARITY to +.
5. Connect VTVM to GENERATOR OUTPUT.
6. Set GENERATOR POWER control to maximum.
7. Read voltage.
8. Repeat all steps for all other settings of the GENERATOR RESISTANCE control.

The voltages should be:

Range	Voltage ± 10%
1 Ω	2.2V
10Ω	6.2V
100Ω	20V
1 KΩ	63V
10 KΩ	200V
100 KΩ	630V

5.1.3 Leakage Resistance Check

To check the leakage resistance from each generator terminal to ground:

1. Connect jumper strap between detector input terminal #1 and ground.
2. Connect generator output terminal #1 to detector input terminal #2 with shielded lead and plug.
3. Cover terminal #2 of generator output with a shield, make sure that the shield does not touch the panel.
4. Adjust the generator output to 600 VDC.
5. Meter should read $\leq$ 600 microvolts. (This is $\geq 10^{12}$ ohms).
6. Connect generator output terminal #2 to detector input terminal #2 using shielded cable and plug. Again, as in test above, don't let plug touch panel.
7. Set generator output to 600 VDC. With detector set on the 10μV range, you should read not more than 6 μV on the meter.

5.2 EMERGENCY MAINTENANCE

CAUTION:

Unqualified personnel must not tamper with this instrument . If the tests outlined in the following paragraphs indicate the need for major repairs, our Service Department will be glad to furnish necessary repair information as well as any replacement parts. If the instrument is more than one year old, a reasonable charge may be expected for replacement parts, or for complete reconditioning if the instrument is returned to the factory. See the Warranty at the back of this Manual.

5.2.1 DETECTOR SECTION

The detector section of the Model 800-R is a specially modified version of the Hewlett-Packard Model 425-A Microvolt-Ammeter. An HP Instruction Manual is included with each instrument. The additions and corrections shown in the front of that Manual should be noticed.

5.2.2 GENERATOR

5.2.2.1 TROUBLE-SHOOTING CHART

SYMPTOM	POSSIBLE CAUSES	HOW TO FIND IT
1. Generator inoperative, PILOT LIGHT NOT LIT.	Before taking cover off: 1. Poor connection to line voltage. 2. Defective fuse. After taking cover off: 1. If, upon replacing fuse the new one blows also, the trouble may be a short in the: (a) Wiring (b) Filter Capacitors, C29-34 (c) Rectifiers, CR4-17 (d) Transformer, T1	Isolate the short by turning down the Generator Power control to its full stop at zero. This effectively eleminates the generator from the circuit. If the short persists, see the HP Manual to trouble-shoot the detector. If the trouble is in the generator: (a) If it persists only on certain Generator Resistance ranges, the trouble is not in T1. This test also indicates which rectifier-filter network the short is in. (b) Disconnect at (A), (B), or (C) of the suspected network. If the short persists, it is probably due to a bad rectifier or shorted Generator Resistance switch. If the short is eliminated, it is probably due to a shorted filter capacitor, or the associated wiring.

SYMPTOM	POSSIBLE CAUSES	HOW TO FIND IT
2. No output on all ranges. PILOT LIGHT LIT.	Before taking cover off: 1. Be sure controls have been set according to Section 2. After taking cover off: 1. Generator switch not making proper contact: (a) Bent contact (b) Inoperative Motor-B2 2. Polarity switch not making proper contact 3. Broken wire or bad solder joint. 4. Open primary on T1.	A quick test for isolating the trouble is accomplished by applying an insulated screwdriver at appropriate points on each switch to insure switch contact.
3. No output on one or more adjacent ranges.	Before taking cover off: 1. Be sure controls have been set according to Section 2. After taking cover off: 1. Generator Resistance switch not making proper contact. 2. Open resistor, R89, 91, 92, 93, 94, 97, 100, 101. 3. Broken wire or bad solder joint.	If the transformer, T1, and the switches are found to be good, all the resistors of the inoperative range should be checked by disconnecting one end and testing with an ohmmeter.
4. Output too low on some ranges.	After taking cover off: 1. One or more rectifiers bad. 2. Shorted turns in secondary of T1.	Isolate the trouble by noting which ranges show difficulty. If trouble is on adjacent ranges using the same rectifier network, the trouble is probably a bad rectifier. A quick test for a bad rectifier is accomplished by using a high impedance voltmeter to check the voltages across each one. In each bridge, the voltage should be the same across each rectifier.

5.2.2.2 REPLACEMENT OF MOTOR-DRIVEN SWITCH ASSEMBLY S4,5,B2

This assembly should always be replaced as a unit, using the following procedure:

1. Note carefully the points to which each wire is connected. We recommend that a diagram or picture be sketched, and that the wires be tagged.
2. Disconnect all wires from the assembly.

3. Disconnect the coupling to S6.
4. Unbolt the assembly from the chassis.
5. Prepare the assembly for safe shipment to the factory.
6. Contact the factory.

H.P. Manual Section Number	Change
cifications	As shown in the "Specifications" section of the 800-R Manual
1 - 1	Delete, "and currents from 1 microampere to 3 miliamperes".
1 - 1	Change to read: "An input resistance of 1.2 megohm on all voltage ranges minimizes errors due to circuit loading."
1 - 1	Change, "It will deliver up to 1 milliampere at 1 volt", to "It will deliver up to 0.83 milliampere at 0.83 volt."
1 - 4	Delete 1 - 4 and add "The 800-R can be converted to 230 volt operation on special order to the factory."
1 - 6	Delete
1 - 7	Delete
2 - 2	Delete. See "How to Measure It" in the 800-R Manual.
2 - 3	Delete
3 - 1	Delete the paragraph beginning "When operated as an ammeter,..."
4 - 3	a. Remove dust cover b. Connect jumper from junction of R_{48}, C_{16} to rotor of R_{47}. c. Set Range Switch on highest range (1000V.) d. Turn instrument ON. Allow 15 minutes for warm-up e. Observe meter. If it ready approximately ZERO (±5% of end-scale), check is complete. f. If meter does not read near ZERO, adjust R_{47}, BIAS adjustment potentiometer, located on rear of instrument, to approximately zero meter. Meter response to this adjustment is sluggish and non-critical.
4 - 4	Delete
4 - 5	Change "d" and "e" to: d. Set DETECTOR RANGE to 1000 V position. e. Connect input of detector to a Dc signal between 1 and 5 volts.
4 - 5	Omit "2".
4 - 9	Delete
4 -10	Delete
	The rest of the Hewlett Packard Manual applies, with the exception of the circuit diagram. The diagram is a part of the 800-R Manual.

REPLACEMENT PARTS LIST (cont'd)

CIRCUIT REF.	DESCRIPTION	MANUFACTURER
R_{91}	Resistor, fixed, composition, 39,000 ohms ± 10%, 2W	Ohmite
R_{92}	Resistor, fixed, composition 47,000 ohms ± 10%, 2W	Ohmite
R_{93}	Resistor, fixed, wirewound 4,500 ohms ±5%, 5W	Ohmite
$R_{94,98}$	Resistor, fixed, composition 33 ohms ±10%, 2W	Ohmite
$R_{95,}$	Resistor, fixed, composition 2,700 ohms ± 10%, 2W	Ohmite
R_{96}	Resistor, fixed, wirewound 1,000 ohms ±5%, 5W	Ohmite
R_{97}	Resistor, fixed, wirewound 50 ohms ±5%, 5W	Ohmite
R 99	Resistor, fixed, wirewound 10 ohms ±5%, 5W	Ohmite
100,101	Resistor, Fixed, wirewound, 1 ohm ± 5%, 3W	Ohmite
R_{103}	Resistor, fixed, composition 27 ohms ± 10%, 1/2W	Allen-Bradley
R_{104}	Resistor, fixed, composition 470,000 ohms ± 10%, 1/2W	Allen-Bradley
R_{105}	Resistor, fixed, composition 200,000 ohms ± 5%, 2W	Ohmite
$DS_{5,6}$	Neon light	GE (NE51H)
S_6	"GEN" switch, wafer	Oak Mfg. (208762-HIC)
$S_{7a,b}$	"POLARITY" switch	ESI (8048)
S_{8-10}	"GENERATOR RESISTANCE" switches	ESI (8050)
T_1	Generator power transformer	Electronic Contractors (#1248)
T_2	Powerstat (Generator Power)	Superior 10B

RECOMMENDED SPARE PARTS LIST
ESI MODEL 800 DC GENERATOR DETECTOR

ITEM	PART NO.	DESCRIPTION	RS
28.	8070	Plate Assy, Interlock Release	1
29.	8106	Release Assy, Interlock	1
30.	8084	Dust Cover	1

*Recommend for sparing to sustain operation for 18 months.

CLAIM FOR DAMAGE IN SHIPMENT

This instrument should be tested upon receipt. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be forwarded to us by the claim agent. We will then advise you of the disposition to be made and arrange for repair or replacement. Include model and serial number when referring to this instrument.

WARRANTY

Electro Scientific Industries, Inc. warrants each instrument and component parts to be free from defects in material and workmanship. Electro Scientific Industries, Inc. will service any instrument and replace parts thereof (except tubes, fuses and batteries) which shall, within one year after making delivery to the original purchaser, prove to be unsatisfactory.

If the fault has been caused by misuse or abnormal conditions or operation, a nominal charge will be made for repairs. In this case, an estimate will be submitted before making such repairs.

Electro Scientific Industries, Inc. reserves the right to make changes in design at any time without incurring obligation to modify units previously purchased.

Electro Scientific Industries

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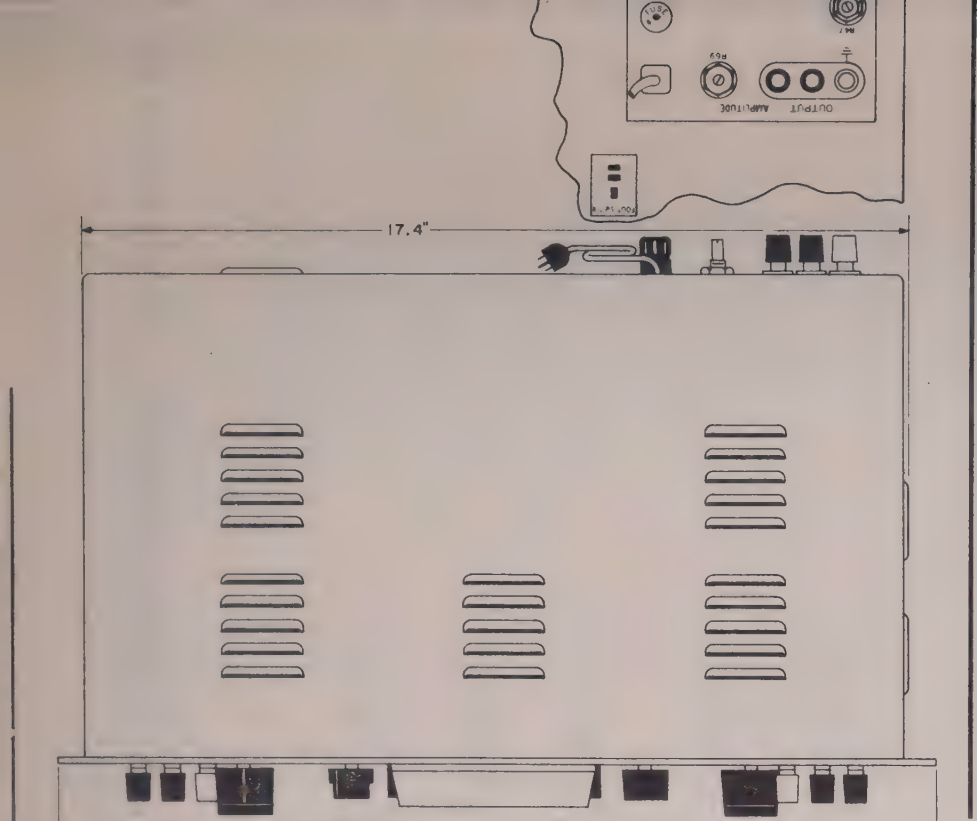
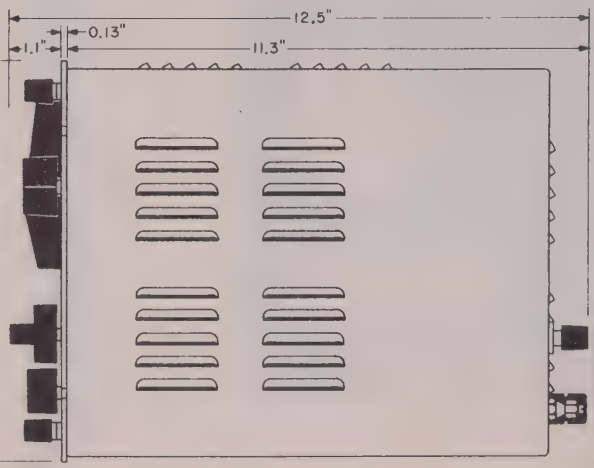
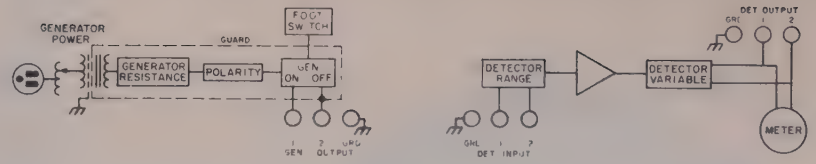
ESI instruments are carefully engineered and made to the most exacting standards of workmanship and accuracy in a modern and well-equipped factory.

Field Engineers are maintained in principal cities as a service to our customers. Customers are invited to contact our nearest field engineer or to consult our engineering staff for further information regarding ESI instruments and their applications.





CIRCUIT SCHEMATIC



SPECIFICATIONS

GENERATOR

RANGE SWITCH: 6 POSITIONS WITH SAFETY INTERLOCK ON 200 V AND 600 V RANGES
OUTPUT CONTROL: CONTINUOUSLY VARIABLE FROM 0 TO 1000 mw INTO MATCHED LOAD
LEAKAGE RESISTANCE: TERMINAL 1 GREATER THAN 10^{14} OHMS. TERMINAL 2 GREATER THAN 10^{11} OHMS

DETECTOR

VOLTAGE RANGE: 0 TO 1000 VOLTS. 0.2 MICROVOLTS PER DIVISION ON LOWEST RANGE
HUM REJECTION: APPROXIMATELY 60 db AT 60 cps
INPUT RESISTANCE: 1.2 MEGOHMS
OUTPUT VOLTAGE: APPROXIMATELY 1 VOLT MAX FOR FULL SCALE
OUTPUT RESISTANCE: 0 TO 2500 OHMS DEPENDING ON OUTPUT SETTING

WEIGHT: 35 LBS NET. 55 LBS PACKED FOR SHIPMENT

model 800

AUGUST 1960

esi Outline Drawing

Electro Scientific Industries

DC GENERATOR DETECTOR

model 800

esi®

Precision Products

Bridges and Accessories

Decade Voltage Dividers

Decade Resistors

Decade Capacitors

ESIAC Computers

Electro Scientific Industries

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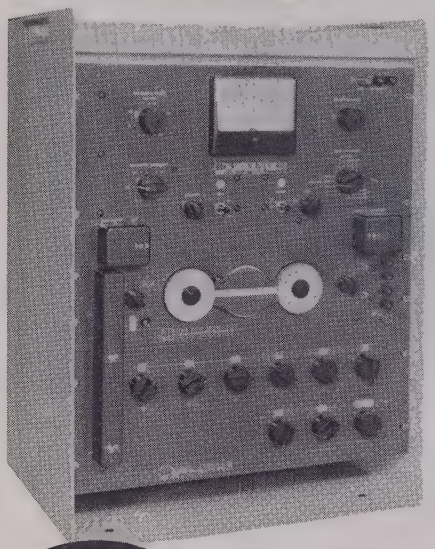
esi **Precision** SYSTEMS FOR



Accuracy ± 0.01%

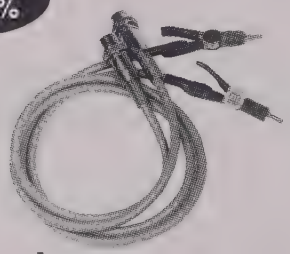
The Measurement System Concept

To attain the accuracy and precision of measurement demanded by modern science and technology requires much more than a precise and reliable measurement instrument.

Accurate measurements also require a judicious combination of (1) basic measurement techniques (2) the implementation of these techniques by carefully chosen instrumentation and (3) the availability of adequate reference standards to calibrate the instrumentation.

Intelligent selection of such parameters as impedance levels, operating voltages and frequencies, detector sensitivities and selectivity and connection methods can insure maximum accuracy throughout a chain of measurements. Properly employed, this chain can be extended to provide direct traceability to reference standards certifiable by the National Bureau of Standards. Specialized transfer standards can be used to simplify the chain and enhance both the accuracy and speed of measurements.

This is the measurement system concept—the integration of design, instrumentation and "state-of-the-art" metrology techniques to provide incisive tools for precise electrical measurements. These ESI measuring systems are specifically designed to meet the demanding requirements of this concept.



KELVIN KLIPS: 4 terminal measurement accessory

Kelvin Klips originally designed for the ESI Model 242 system—now available for making rapid, precision four-terminal resistance measurements even with relatively high lead and contact resistances. Kelvin Klips also provide a strong reliable low resistance, long life, all-purpose test clip for two-terminal applications. Price $7.50 for Klips only, or $25.00 assembled with shielded cable and spade lug terminations. Request Catalog Sheet C-31.

MODEL 242 RESISTANCE MEASURING SYSTEM

A precision resistance bridge of wide range, superior accuracy and extreme resolution. Compares the percentage difference between the unknown resistance and the product of the standard resistance times the multiplier. Bridge multiplier accurate to better than ±0.005%. Comparisons to an accuracy of 1 ppm are possible by using substitution techniques. Measurements of ±0.01% accuracy can be made directly without calibration and with no need for zero resistance or lead resistance correction. With a set of Model SR-1010 Resistance Transfer Standards, measurements over a wide resistance range are traceable to an NBS certified standard with an accuracy of a few ppm.

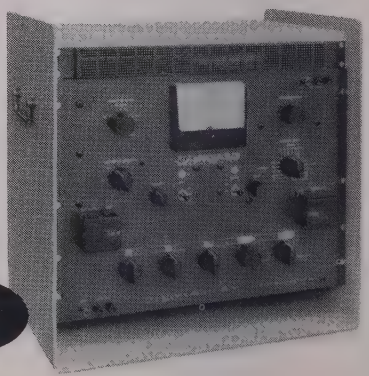
242—Resistance Measuring System—Ratio bridge, decade standard, and generator-detector in case with Kelvin Klips	$3,400.00*
241—Resistance Comparison System—Ratio bridge and generator-detector in case	2,300.00*
243—Ratio bridge and decade standard in case	2,200.00*
240—Kelvin Ratio Bridge (Less Accessories)	900.00*
800—DC Generator-Detector	1,300.00*
RS-925—Decade Resistance Standard—0.01 ohm to 1.2 megohm, with 0.0001 ohm resolution in four-terminal connection	1,200.00*
SR-1010—Resistance Transfer Standards (See separate description on Standards page)	each 250.00*

Request Catalog Sheet C-27 and Design Ideas Volume 1, 2 and 3.

MODEL 231-A GUARDED WHEATSTONE RESISTANCE MEASURING SYSTEM

A precision, high resolution Wheatstone bridge. Five place readings; initial accuracy of ±0.005%, long term accuracy ±0.01%. Human engineered for simple operation and direct readout. Automatic decimal point location. Internal guarding permits accurate, high resolution measurements to 12 kilomegohms. Matching generator-detector provides 6 output ranges to match loads from 1 ohm to 100 kilohms. Mounted in attractive, rugged case.

231-A—Resistance Measuring Assembly (With Accessories)	$1,875.00*
230-A—Guarded Resistance Bridge (Less Accessories)	450.00*
800—Generator-Detector	1.300.00*



Accuracy ± 0.01%

For Further Information Request Catalog Sheet C-21.

***All prices f.o.b. Portland, Oregon.**

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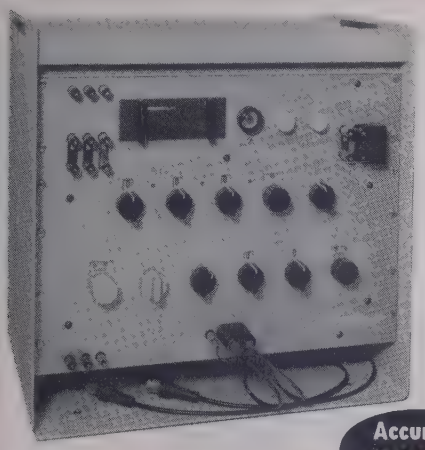
Precision MEASUREMENTS

esi



Accuracy ± 0.01%

MODEL 700-A CAPACITANCE MEASURING SYSTEM

Both two- and three-terminal capacitors in the range from 0 to 1.2 microfarads can be measured. The resolution of the lowest range is 100 micro-picofarads (10^{-4} pf) per dial division. The resolution of the deviation dials is 0.001% (10 ppm) at all capacitance settings.

Deviation dials and complete bridge shielding provide for extremely accurate comparison of capacitors. For example, one picofarad standards can be compared to better than ten micro-picofarads (10^{-5} pf).

The bridge uses a ratio transformer circuit and a specially-designed, hermetically-sealed air capacitor having a very low temperature coefficient of capacitance and an exceptional stability. Accuracy of the measured capacitance is referred to this one standard which can be periodically checked and adjusted to agree with an NBS certified standard. This assures a minimum of drift due to changes of altitude, room temperature, voltage and frequency.

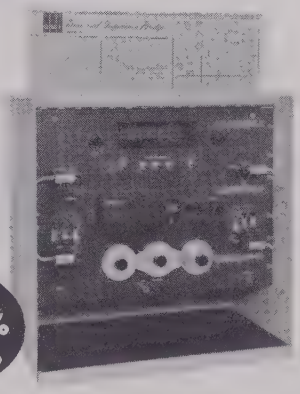
High input voltage capability (up to 350 volts at 1 kc) greatly increases measurement sensitivity.

700-A—Capacitance Measuring System/with cabinet $1725.00*
707-A—Capacitance Bridge 1350.00*
860-B—Generator-Detector 275.00*
SC-1000—Capacitance Standard (see separate description on next page.)

For Further Information Request Catalog Sheet C-28.

MODEL 291-A IMPEDANCE MEASURING SYSTEM

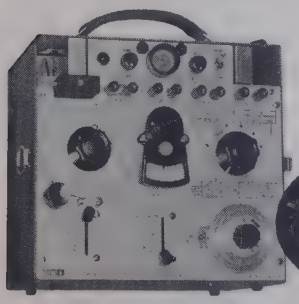
Outstanding accuracy combined with simplicity of operation. Dc and ac impedance measurements covering seven decades of inductance, capacitance, resistance and conductance, and three decades of D and Q. Five place readings. Resistance and conductance accuracy to 0.05%. Inductance and capacitance accuracy to 0.1%. Complete with line operated ac and dc generator-detector units designed specifically as companion units for the bridge. Mounted in an attractive case with operating instructions in the cover and an insulating platform for supporting components under test.



291-A—Impedance Measuring System (With Accessories) $1,095.00*
290-A—Universal Impedance Bridge (Less Accessories) 495.00*
840—DC Generator-Detector 280.00*
860—AC Generator-Detector 250.00*

Accuracy R&G ± 0.05% L&C ± 0.1%

For Further Information Request Catalog Sheet C-13.



Accuracy R ± 0.1% C ± 0.2% L ± 0.3%

MODEL 250 PORTABLE IMPEDANCE BRIDGE

A self-contained, line-operated portable unit for making accurate measurement of impedance elements at dc and audio frequencies. Accuracy ratings of ±0.1% for resistance, ±0.2% for capacitance, and ±0.3% for inductance. D and Q measurements for capacitors and inductors. Price: $495.00*

MODEL 250-C1—The battery-powered version of the bridge, complete, less headphones. Price: $340.00*

MODEL 855-A1—A line-operated generator and detector for Model 250-C1. The combination is essentially equivalent to the Model 250-DA but has greater versatility for specialized measurements. Price: $170.00*

For Further Information Request Catalog Sheet C-16.

MODEL 270 CAPACITANCE BRIDGE

Accurate measurements of capacitance and dissipation factor at audio frequencies. Simple calibration adjustment against reference standards. Accuracy ±0.1%; resolution 0.01%. Three-terminal connections; no zero capacitance correction. Seven capacitance ranges; three dissipation factor ranges.

MODEL 270—0 to 120 μf; 0.01 μμf resolution on lowest range. Price: $575.00*

MODEL 270-H—Capacitance and dissipation factor ranges raised by a factor of ten; recommended at lower frequencies. Price: $650.00*

MODEL 270-L—Capacitance ranges lowered by a factor of ten; low range resolution 0.001 μμf. Price: $650.00*

For Further Information Request Catalog Sheet C-15.

Accuracy ± 0.1%

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esi **Standards** AND

MODEL SR-1010 RESISTANCE TRANSFER STANDARD

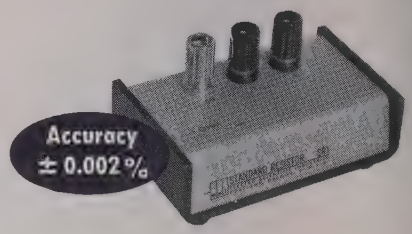
Twelve equal resistors in a box, for transferring resistance measurements from a standard of one value to a resistance at a different value. Each resistor within ±0.005% of nominal value; short term stability suitable for comparisons of one part to a million. Designed for standardizing two-terminal and four-terminal resistance bridges, voltage dividers and ratio sets. Special junction design allows four-terminal series and parallel measurements without junction errors. Standard values: 1, 10, 100, 1K, 10K, 100K ohms (per resistor).

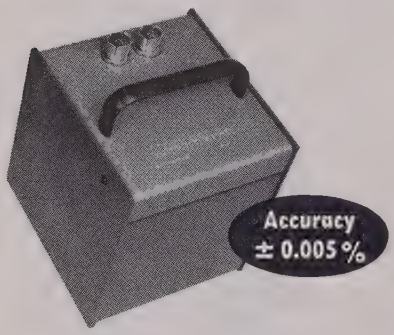
For Further Information Request Catalog Sheet C-30. Price: $250.00* each

MODEL SR-1 STANDARD RESISTOR

A small rugged laboratory standard resistor of high accuracy and stability, with low reactance and low temperature coefficient. They are supplied with an initial reading accurate to ±0.002% and have a long term stability guaranteed to ±0.005%. Two, three and four-terminal measurements are possible. Standard values: 1, 10, 100, 1,000, 10K and 100K ohms. Price: $15.00* each

For Further Information Request Catalog Sheet C-29.





MODEL SC-1000 CAPACITANCE STANDARD

The Model SC-1000 Capacitance Standard is a stable, precise, one nanofarad (0.001μf) capacitor with a guaranteed three-terminal accuracy of 50 ppm (0.005%). These capacitors provide a stable transfer unit of a convenient value for calibrating bridges or other capacitors.

Stability is assured by strong mechanical construction of the air-spaced capacitor plates. The choice of plate and spacer materials insures a temperature coefficient of capacitance less than 5 ppm per degree centigrade. Hermetic sealing keeps the capacitance constant even though the dielectric constant of air changes with altitude almost 0.01% between sea level and 5,000 feet. Price, $250.00, f.o.b. Portland, Oregon.

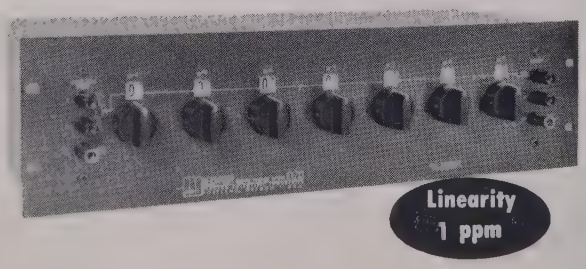
For Further Information Request Catalog Sheet C-35.

MODEL DT-72A DEKATRAN DECADE TRANSFORMER

A laboratory standard transformer-type ac decade voltage divider providing certified linearity starting at ½ ppm at larger dial settings and improving to better than 1/100 ppm at small settings. All units certified at the factory as a primary ratio standard in terms of an ESI standard traceable to the National Bureau of Standards.

Price: With ESI guarantee of specified linearity.....$695.00*
With ESI guarantee and certificate containing calibration readings with linearity accuracy of ½ ppm or better.....$795.00*

For further Information Request Catalog Sheet C-25.



MODEL RV-722
KELVIN VARLEY VOLTAGE DIVIDER

A precision resistive DC voltage divider providing 1 ppm terminal linearity at full setting, and seven dial readout with 0.1 ppm resolution. One year stability of 1 ppm is assured at full setting. Output at zero setting is less than 0.004 ppm of input. A calibration certificate is included containing initial calibration readings accurate to 0.5 ppm linearity at the time of final inspection. Price: $950.00*

For Further Information Request Catalog Sheet C-14.

***All prices f.o.b. Portland, Oregon.**

Electro Scientific Industries

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Decade Units

esi

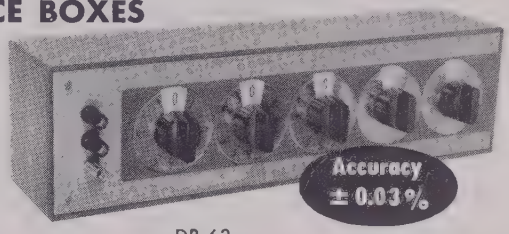
DEKASTAT® and DEKABOX® DECADE RESISTORS

Adjustable resistance standards of high accuracy containing one or more decades of precision fixed resistors. Some models include an interpolating rheostat. Accuracies to 0.005% initial, 0.02% long term. Temperature coefficient less than ± 5 ppm per degree Centigrade. Model DS Dekastat for panel mounting. Model DB Dekabox for bench use, Model RS Dekastat for rack mounting.

Prices: from $63.00 to $550.00*

For Further Information Request Catalog Sheet C-18.

DEKABOX®
IN-LINE DECADE RESISTANCE BOXES



Units may be obtained with four, five, and six decades with resolutions rom 10 milliohms per step.

ndividual resistors of 100 ohms and above have a temperature coeffiient of 10 ppm/°C. and resistors below 100 ohms 20 ppm/°C. Accuracy f adjusment of decades is ± (0.03% + 1 milliohm/decade.) Total ero resistance of each box is 10 milliohms.

The units are offered with total resistance values from 111.1 ohms to 1.11110 megohms.

Steps	DB-42 4 dials	DB-52 5 dials	DB-62 6 dials
0.01 Ω	111.1 Ω $125.00	1.11110 K $150.00	11.11110 K ...$175.00
0.1 Ω	1.1110 K $100.00	11.1110 K $125.00	111.1110 K ...$150.00
1Ω	11.110 K 100.00	111.110 K 125.00	1.111110 meg . 160.00
10 Ω	111.100 K 100.00	1.11110 meg . 135.00	11.11110 meg . 195.00
100 Ω	1.111000 meg . 110.00	11.1110 meg .. 170.00	.....
1 K	11.11000 meg . 145.00	.....	.....

above prices f.o.b. Portland, Oregon

DEKAPACITOR® and DEKABOX® DECADE CAPACITORS

Adjustable, low loss decade units. Hermetically sealed polystyrene capacitors except below 1000 picofarads where high quality ceramic or mica capacitors are used. Accuracy 1%. Model DK-30 Dekapacitor for panel mounting. Model DC-40 Dekabox for bench use.

DK-30: 1μf—3 decades, for panel mounting. Price: $200.00*

DC-40: 1μf—4 decades, bench mount. Price: $240.00*

For Further Information Request Catalog Sheet C-18.

DEKAPOT® DECADE VOLTAGE DIVIDERS

The Dekapot contains one or more resistive Kelvin-Varley decades and an nterpolating potentiometer to provide high resolution and accurate voltge divisions. They are designed for panel mounting and utilize the exclue ESI Dekadial concentric dials for direct in-line readout. Linearity from ±0.1% to ±0.005%. Price: from $69.00 to $175.00*

MODEL DP-451—A militarized version of the ESI Model DP-211. Certified o meet the environmental test requirements of MIL-T-945A. The electrical pecifications are identical to that of the DP-211. Standard values: 1K, 10K, nd 100K. Price: from $145.00 to $160.00*

or Further Information Request Catalog Sheet C-23.

***All prices f.o.b. Portland, Oregon. Quantity discounts available.**

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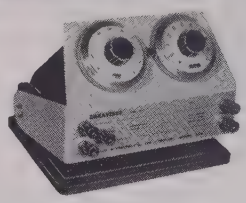
esi Dividers AND Networks



Linearity ± 0.001 %

DEKAVIDER® DECADE VOLTAGE DIVIDERS

Resistive voltage dividers using the Kelvin-Varley circuit.

In-line control knobs on the rack mounted divider and the exclusive ESI Deka-dial® coaxial dial of the bench mounted unit simplify dial settings and permit easy in-line readings. For use from dc through audio frequencies.

RV-622A: precision resistors closely matched for maximum accuracy. Linearity 10 ppm, resolution 0.0001%. 10K Price: $450.00*
100K Price: $500.00*

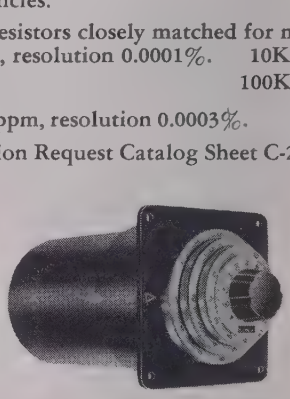
DV-411: linearity 50 ppm, resolution 0.0003%. Price: $145.00*

For Further Information Request Catalog Sheet C-23.

DEKATRAN DECADE TRANSFORMERS

Decade transformers providing exceptional accuracy over a wide range of environmental conditions.

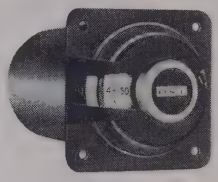
MODEL DT-45: three decades plus an interpolating potentiometer give accurate five-place readings of voltage ratio (linearity and resolution to 10 ppm).



MODEL DT-35: two decades plus an interpolating potentiometer give accurate four-place readings (linearity and resolution to 100 ppm). All units designed for panel mounting. Price: DT-35, $160.00*; DT-45, $265.00*

For Further Information Request Catalog Sheet C-22 (DT-45); C-24 (DT-35).

Linearity ± 0.001 %



Accuracy ± 0.005 %

MODEL SV-194B VOLTAGE CALIBRATOR

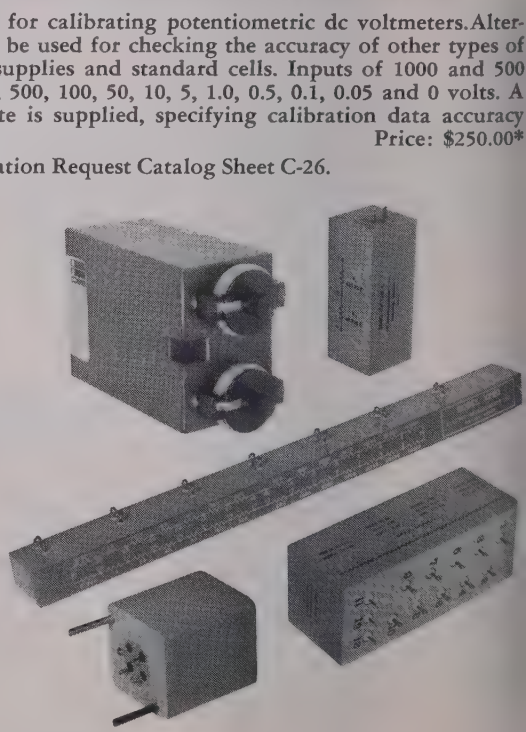
A precision divider for calibrating potentiometric dc voltmeters. Alternate techniques can be used for checking the accuracy of other types of voltmeters, power supplies and standard cells. Inputs of 1000 and 500 volts; outputs 1000, 500, 100, 50, 10, 5, 1.0, 0.5, 0.1, 0.05 and 0 volts. A calibration certificate is supplied, specifying calibration data accuracy to ±0.005%. Price: $250.00*

For Further Information Request Catalog Sheet C-26.

CUSTOM RESISTOR NETWORKS

High precision custom resistor networks are available to meet specific requirements. The resistors used are wound with wire which has a temperature coefficient less than ± 2 ppm per degree Centigrade, and are adjusted to extremely close tolerance after being put through a special aging process. The ruggedness and stability of ESI resistors makes them suitable for networks for field use, under difficult environmental test conditions. In laboratory applications, accuracies similar to those of ESI standard resistors can be supplied. In order to assure high reliability and accuracy, ESI networks are sold only mounted in suitable enclosures. ESI custom networks represent the solution to problems in temperature coefficient matching and special packaging.

Individual quotations will be made upon request.



***All prices f.o.b. Portland, Oregon.**

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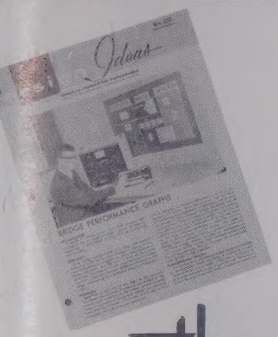


QUARTERLY TECHNICAL PUBLICATION—"DESIGN IDEAS"

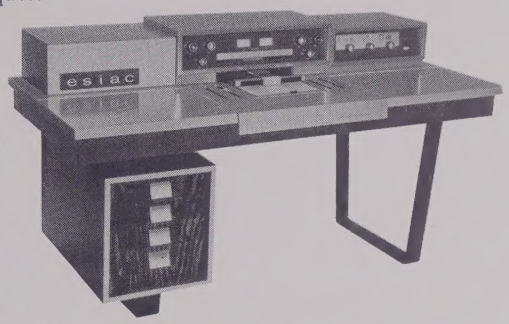
ESI publishes a quarterly release called "Design Ideas." Its purpose is to inform our customers of advanced techniques and applications in the field of precision measurements. It also indicates ESI's progress in applying these techniques to development of "state of the art" equipment and procedures. Issues published covered such subjects as voltage divider calibration, precision resistance measurements and bridge performance graphs. The publications are mailed without charge upon request.

the esiac®

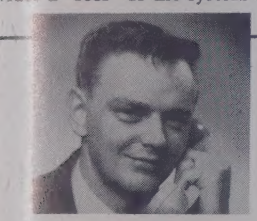
A NEW APPROACH TO SYSTEM DESIGN

Model 10 ESIAC ALGEBRAIC COMPUTER calculates solutions for the racteristic equations of circuits and control systems. The results are presented oot-locus plots and Bode phase and gain diagrams. The root locus technique sed to find closed loop response from open loop data for feedback controlled ems and it is also used for factoring polynomials. Bode plots present frequency onse in terms of gain and phase shift.

Rapid pole-zero programming allows the ESIAC user to study quickly the effect hanges in system parameters or components. For example, the poles and zeros compensating network can be added to correct an unstable system. The results be analyzed by a new root-locus plot in a matter of minutes. The ESIAC vides a "feel" of the system that no other computer can equal.



Solves intricate system design problems in minutes instead of hours, hours instead of days. Write on your company letterhead for new 30-page brochure on theory, operation, advantages and typical, problem-solving appliactions of the ESIAC algebraic computer in dynamic systems design.



TALK TO AN ESI ENGINEER — AT NO COST TO YOU

Any questions? Use your phone. Get the answers fast, accurately, first-hand from an ESI applications engineer at the factory. The numbers below are listed in your local directory. No long distance charges. Dial operator—ask for:

NEW ENGLAND & MIDDLE ATLANTIC

Wilmington, Del.	Enterprise 1-0384
Baltimore, Md.	Enterprise 9-3350
Andover, Mass.	Enterprise 3331
Boston, Mass.	Enterprise 3331
Cambridge, Mass.	Enterprise 3331
Lexington, Mass. (Including Bedford)	Enterprise 3331
Pittsfield, Mass.	Enterprise 3331
Waltham, Mass.	Enterprise 3331
Wayland, Mass.	Enterprise 3331
Wilmington, Mass.	Enterprise 3331
Camden, N. J.	WX 6619
Eatontown, N. J.	WX 6619
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Buffalo, N. Y.	Enterprise 6619
Endicott, N. Y.	Enterprise 6619
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Manhattan, N. Y.	Enterprise 6619
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San Matéo, Calif.	Enterprise 1-3031
Sunnyvale, Calif.	Enterprise 1-3031
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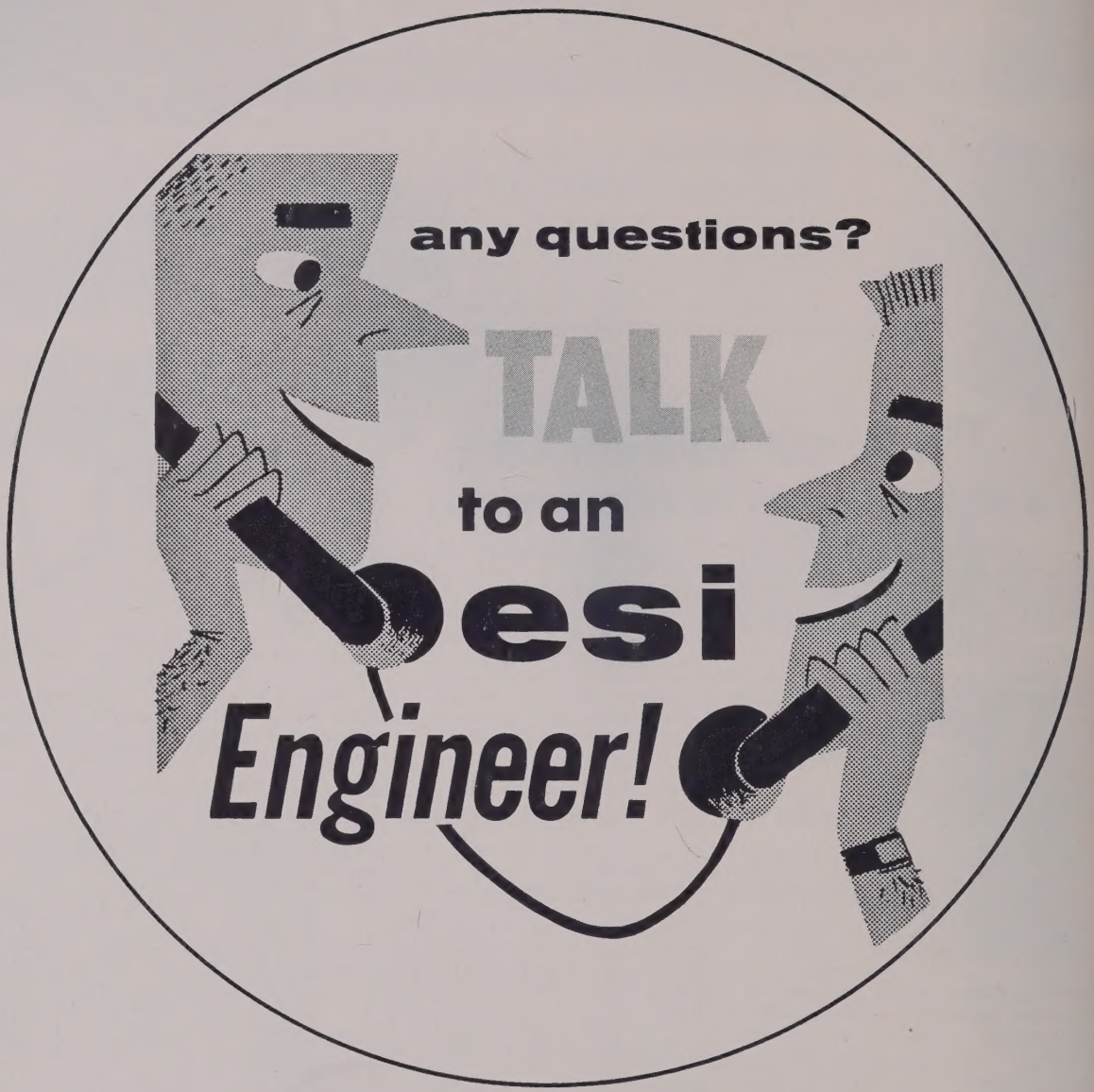

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To better serve you, ESI now maintains local directory listings in all principal marketing areas throughout the nation.

These numbers provide direct, toll-free telephone service to our plant in Portland and to our special engineering sales-service department.

Staff members are specialists in the electronic measurements field, thoroughly familiar with ESI products and applications. Their technical knowledge and engineering skills are available to you as quickly and conveniently as calling across town or to the next office.

When you have a measurement question—or need engineering, purchasing or service information—use your phone, the ESI (easy) way. Get the answers fast, accurately and first-hand from an ESI applications engineer at the factory.

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